THE GLASS INDUSTRY

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GLASS DIVISION MEETS AT ABSECON

The first question the members of the Glass Division of the American Ceramic Society asked each other as they began to assemble on Friday morning was, "When did you learn to pronounce Abseekon?" The usual informant was a native or a railroad man. The Seaview Country Club was named by some far-sighted individual, but the appointments were excellent and the golf course a splendid, rangy layout, well trapped. Winners of the tournament were: Low Gross Contest—Mr. C. T. Uhrmann; Low Net Contest—Mr. R. M. Curts; Special Contest—Mr. J. J. Moran; Flag Contest—Mr. F. D. Pinotti; Kickers Contest—1st, Mr. G. Stewart; 2nd, Mr. G. Love; 3rd, Mr. C. Cruikshank; and 4th Mr. H. Brown. Registrations numbering about sixty-five were efficiently handled by Vice Chairman Joe Greene and his capable secretary. The room set aside for the meetings was large and well arranged with comfortable chairs. There were no mosquitoes indoors.

At the opening session on Friday afternoon, General Secretary Ross Purdy displayed and formally presented to the Division a replica in color of the oil painting of Professor W. E. S. Turner sent to us by Geoffrey Marchand, Honorary Secretary, Society of Glass Technology. Dr. Purdy gave a fitting appreciation of the career of Professor Turner, eulogizing his tremendous services to the science of glass technology under physical handicaps which would seriously have hampered the career of any man of less brilliance and energy. It was voted gratefully to accept the picture and to entrust it to the general Secretary for safe keeping in the offices of the Society in Columbus. Chairman W. C. Taylor appointed Messrs. Flint, Sharp, and Hostetter as a committee to draw up a suitable resolution in appreciation of this gift from our British friends.

The technical session opened with an informal statement by a representative of the War Production Board, covering "The Present Situation on Fuels and Materials." These remarks were not made for publication, and we are not entitled to report quantitatively on any of the items considered. It appeared, however, that none of the heavier chemicals used in the common glasses exhibit shortages at present. Even soda ash which was scarce in 1941, is now being produced in sufficient quantity so that our industry receives its full share. However, some of the refining agents and coloring oxides, also the purer sources of alumina, must be considered scarce so far as we are concerned. Something of a dilemma exists in the matter of fuels because, although conversion to producer gas operation is desirable, those factories which do not have producers can hardly expect to construct them under the existing conditions.

In his talk on "Replacement of Natural Gas by Oil Fuel," Gerald Fitzgerald, Maxon Premix Burner Co., New York, stressed the importance of handling fuel oil properly, both in preparatory heat and in its atomization. He pointed out that as much as 25 per cent of the fuel oil may be wasted when it is improperly burned under a boiler, and a similar figure might apply to its reckless use in the glass furnace. The speaker remarked that the oil burner should be fitted to the furnace and not the furnace to the oil burner; that imperfect atomization harms brick work because liquid oil is sometimes thrown against the refractory where it carbonizes and causes rapid deteriorization. He was not particularly in favor of any especial grade of fuel oil but maintained that any oil can be burned if it is brought to the burner in a properly fluid condition. He deplored the practice of heating the entire contents of a storage tank over long periods since this results in increased sedimentation and eventual clogging of burners if not of pipe lines.

E. S. Hammond, Bloomfield, N. J., presented ideas which were the result of long practical experience in burning all types of fuel oil. On the whole, he gave an encouraging picture which should go far toward relieving any anxiety that operators may feel if they are obliged to turn to oil fuel in the event of a shortage of natural gas. Mr. Hammond's remarks concerning the efficacy of oil burners placed in the back wall of close-fired generative tanks aroused some discussion from the floor. He insisted, however, that his experience showed that it was quite practical to atomize the oil in such a way that it could be blown lengthwise of the furnace across the port mouths in such a way as to maintain proper combustion with the incoming air at all the ports. He also emphasized the importance of proper burner construction, especially as to size to suit the type and area of the furnace being heated.

A photostat copy of a report by the Furnace Committee of the Society of Glass Technology was read in part by Mr. Greene. This report undertakes to assess the performance of glasstank furnaces, and rather elaborate mathematical treatment has been accorded to the subject, altogether out of line with our usual idea of furnace efficiency based on the ratio of glass made to fuel used. This committee calculated the performance of a furnace in terms of heat units per second supplied to the furnace per square foot of total area on a no-load basis. In this way, they have eliminated the variable factors of size temperature, rate of pull, and fuel quality, not to mention the color and type of glass being melted. The figures suggested for good performance are: under 5 B.t.u. per square foot per second, "good"; between 5 and 6, "fair"; between 6 and 7, "poor"; and over 7, "bad." However, these figures refer to standard conditions of 600-square-foot area and 1400 degree C. temperature. In other words, this report suggests that any furnace which can be successfully heated on this area and temperature basis with less than 5 B.t.u. per square foot per second is a

GLASS DIVISION at ABSECON

A few shots of glassmen off duty. Contributed by E. L. Hettinger and Dudley C. Smith.

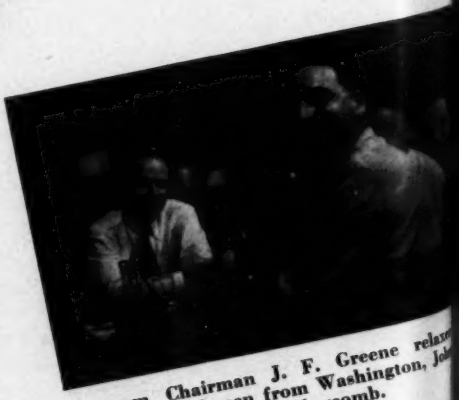
V. V. Kelsey and L. G. Gehring watch Carl T. Uhrmann take first prize.

Carl Herzig keeps score for J. C. Keaney, G. L. and W. Henry.

In this corner Messrs. Flint and Sharp fight it out.

The Oscar Hommel Trophy.

C. L. Cruikshank steps across the green anxious to sink this one.



Program Chairman J. F. Greene relaxes with two gentlemen from Washington, John R. Hostetter and Rex Newcomb.

Dudley C. Smith of Kimble has a story as to how it happened—maybe he dropped one of those glass stories.

Glass Division Chairman W. C. Taylor and H. R. Lillie walk the course.

George W. Oakley of Corning Glass Works backs up "Doc" Shively while R. M. [illegible] looks on.

No identification needed.

good furnace, regardless of the quantity or quality of glass produced in comparison with the fuel used. The Vice Chairman pointed to the "poisonous" pages of mathematics involved in which were included certain factors for correcting the furnace to standard size and the temperature to the standard 1400 degrees C. Further acquaintance with the material presented as it finally appears in print may cause some changes of heart, but in general the members did not feel in agreement with the proposals of this committee.

On Saturday morning Messrs. Zarbo Hunt, and Smith of the Kimble Glass Company presented a method for the chemical analysis of cords and stones in glass. One of the interesting features was the preparation of samples by heating the glass and drawing it away from the stones and knots in such a manner as to leave very small samples consisting principally of the troublesome material for analysis. The procedures involved semi-micro determinations, particularly of silica and alumina, and comparison of the values with the values found in the oxides of the parent glass.

Anyone who has attempted to demonstrate the character of cords and stones by chemical analysis will appreciate that this application of the semi-micro method with samples weighing as little as fifty miligrams offers a step in advance of anything that could be done by the ordinary full-scale quantitative analysis. Tabulations and pictures of the apparatus were well presented by slides, and a box of the equipment used was exhibited for the benefit of those unfamiliar with the procedure. This paper should furnish an interesting publication.

R. A. Miller, Pittsburgh Plate Glass Company, exhibited a series of motion picture films showing the results of some extended work on the behavior of glazing materials subjected to explosions. An actual nine-foot building with one opening glazed (temporarily) by various sheets of material faced the explosive wave caused by several sticks of dynamite set off by electric charge a measured distance away from the front of the building. The results were shocking, and the experimenters and Mr. Miller are to be congratulated on a bang-up presentation. Any lingering belief in the efficacy of strips of paper pasted across windows or sheets of plastic as safeguards against explosion breakage was certainly removed by the demonstration. Perhaps the most interesting feature of the experiments was the demonstrations of the reliability of the Bureau of Mines formula concerning the degree of explosion shock: $\frac{\sqrt[3]{\text{number sticks dynamite.}}}{\text{distance}}$ The stick of dynamite referred to is the standard half-pound. Slow motion was resorted to, to show the waving of the panes before breakage occurred and the indeterminate way in which the window might be blown either inward or outward, depending upon the responsive timing of the compression and vacuum in the explosion wave.

At a brief business session, Mr. Greene spoke in favor of returning to the practice of having a Second Vice Chairman as an assistant to the Vice Chairman in the preparation of programs, particularly for the summer meetings. On motion duly carried, the Chairman was authorized to appoint an acting Second Vice Chairman for the remainder of this year, and it seemed to be the general opinion that the Division would do well to make this replacement on its list of officers.

At the Division dinner in the evening a pianist was present who could and did play practically all the songs that the members knew how to sing, and some that they did not. The party then broke up into groups for conversation, bridge, and other diversions.

Committee C14 of A. S. T. M. met for organization purposes, with vice-chairman E. W. Tillotson presiding, in the absence of Dr. J. C. Hostetter.

SUMMARIES OF TECHNICAL PAPERS

The Present Situation in Regard to Glass Making Raw Materials. *By John R. Hostetter, Chemicals Branch, W.P.B., Washington, D. C.*

Mr. Hostetter, speaking in an unofficial capacity, briefly reviewed the various conservation orders as they apply to some of the glass making materials. In the case of soda ash a recent amendment to the Order M-161, which regulated inventories of soda ash, now lifts these restrictions and allows the user to build up a stock pile. This has been done so as to safeguard against any transportation difficulties that may occur this winter. In addition there is a possibility that new expansion programs in the soda ash industry may relieve any shortages.

Due to the requirements of the Army and agriculture the arsenic situation has changed and the use of arsenic will only be allowed for special glasses such as optical glasses, special bulb glasses, tubing and the like. Antimony may or may not be available as a substitute.

The present position of fluorspar, cryolite, barium carbonate, barium sulphate, aluminum trihydrate, fuel oil and gas were also discussed and it was emphasized that the present position of any material is not stable and that the picture of each or all may be changed overnight.

Replacement of Natural Gas by Oil Fuel. *By Gerald FitzGerald, Maxon Premix Burner Co., New York, N. Y.*

Mr. FitzGerald's paper was in the nature of an informal account of his experiences in converting various furnaces to different fuels during the past 25 years. In summing up, the author pointed out that the furnace is really the burner and that the burner is really an atomizer, an inspirator or a proportioner. This being the case, successful installations require a good burner and a well designed application. Proper attention should be paid to efficient utilization of fuel, but not at the expense of the product manufactured.

Replacement of Natural Gas by Oil Fuel. *By E. S. Hammond, Bloomfield, N. J.*

Mr. Hammond briefly reviewed many of the problems connected with the use of fuel oil in firing glass furnaces such as dirty oil, heating of the oil, and the proper position of the burner in the furnace.

In the author's opinion much of the troubles due to dirty oil are caused by faulty methods of heating the oil in the storage tanks. In many cases the oil is stored in large tanks having capacities far greater than the actual daily use. The heating arrangements in these tanks are such that the entire volume of oil in the tank is heated. This continued application of heat causes the oil to precipitate out various carbonaceous materials which build up on the bottom of the storage tank as a sludge and which, in many cases, requires that the delivery lines from the tanks must be raised and the tank itself cleaned frequently. It was recommended that the storage tank be so designed that only a small portion of the oil be heated and then not to temperatures in excess of 140° F.

In the glass furnace application that the author was most familiar with, the oil was introduced into the furnace by the means of single burners located on each side of the doghouse. Such a location allowed a very flexible control over the length and width of the flame.

(*Continued on page* 395)

ON THE SPECTRAL TRANSMISSION OF COLORED CONTAINER GLASS[1]

By DONALD E. SHARP*

PART II

EDITOR'S NOTE

The previous installment of this article dealt with methods of measurement, with an explanation of the terms and symbols used in discussing transmission, and with procedure for calculating transmission for various thicknesses. In the current installment data are given on spectral transmissions of some 34 commercial glasses. Figure I, which through an oversight was omitted from the first installment, is included here.

Transmission of the Colored Glasses

In some cases the samples that were available were not thick enough to finish to 2 mm., but wherever conditions permitted an attempt was made to grind and polish the glass to this thickness. The color of the glasses, and actual thicknesses of the samples measured are given in Table V.

To permit ready comparison of glasses, transmissions were all calculated to values for a thickness of 2 mm. and these calculated data are listed in Tables VI, VII, VIII and IX.

Table VI lists the percentage transmission of fifteen commercial amber container glasses, and of a flint glass stained on the surface. Data on the transmission of a variety of green glasses are given in Table VII. In Table VIII are listed data on four commercial blue glasses colored by cobalt, and one glass made in the laboratory and colored by copper. Table IX furnishes data on a few miscellaneous glasses that have been made in commercial quantities but not necessarily in the form of containers, and on some pieces of colored cellophane purchased at a stationer's.

It will be noted that there is considerable difference in the transmission of the amber glasses from different factories. While the transmissions of all these glasses are greatest for the long wavelengths and least for the short wavelengths, the detailed character of the transmission varies considerably from glass to glass.

To facilitate further comparison of the characteristics of the glasses, the transmission data have been plotted against wavelength for several of the glasses. Figures 2 and 3 show the approximate minimum and maximum transmissions found in the commercial amber glasses. From the figure and the data it is seen that glasses Nos. 6621 and 7427 are roughly representative of the average of the amber glasses and the transmissions of these are plotted in Figure 4. To show the effect of thickness on

TABLE V.

List of Glasses Examined and Thickness of Samples

No.	*Color*	*Thickness*	*No.*	*Color*	*Thickness*
6561	Amber	1.03	6559	Light Green	1.59
6562	"	1.84	6560	Coca Cola Green	1.79
6563	"	1.83	6755	Emerald Green	1.52
6572	"	2.0	6707	" "	2.27
6573	"	2.0	6865	" "	2.21
6574	"	2.0	7204	" "	2.4
6597	"	2.0	8209	" "	2.17
6584	"	1.9	8210	Champagne Btl. Green	1.70
6598	"	2.83	6618	Light Blue (Co)	1.8
6604	"	2.0	6557	" " "	1.89
6621	"	1.7	6619	Dark Blue (Co)	1.9
6622	"	1.9	6558	" " "	1.95
6637	"	2.05	8866	Blue (Copper)	1.94
6638	"	2.08	6575	Flint, Milk Btl.	6.7
6651	"	2.48	8568	Flint	1.17
7427	"	2.05	8580	Copper Ruby	2.0
8208	"	1.31	A101	Heat Absorbing (Greenish)	6.15
8569	Yellow Surface Stain				

TABLE VI

SPECTRAL TRANSMISSION OF AMBER CONTAINER GLASSES

Wave Length mμ	*Glass No.* 6561	6562	6563	6572	6573	6574	6584	6597	6598	6604	6621	6622	6637	6638	6651	7427	8208	8569
289	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—	—	—
297	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—	—	—
302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—	—	—
313	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—
334	1.1	4.4	7.0	10.5	0	4.0	2.1	12.5	8.2	3.0	3.7	0	8.4	1.7	5.3	3.5	2.2	—
365	1.9	3.9	9.2	11.0	0	3.0	2.6	13.0	9.1	3.5	5.5	0	11.5	2.3	6.8	5.6	2.3	22.3
400	1.2	1.4	4.5	5.5	0	1.0	0.8	7.4	3.2	1.4	2.0	0	5.8	0.6	3.2	2.6	1.1	14.0
425	1.5	1.6	4.9	5.5	0.2	1.2	1.0	7.7	3.4	1.4	2.3	0	6.0	0.6	3.4	4.5	1.1	14.9
450	3.0	3.4	8.3	9.6	0.8	2.7	2.6	12.5	6.1	3.1	4.4	0.3	10.2	1.5	6.3	6.3	3.0	17.8
475	7.8	9.0	16.4	18.5	3.2	7.6	7.0	22.0	13.8	8.2	10.5	1.9	18.8	4.8	13.2	11.4	6.9	24.6
500	17.3	19.0	29.0	30.6	9.3	17.7	16.0	36.0	26.2	18.3	21.0	6.6	32.0	12.6	25.2	21.6	16.0	36.6
525	30.2	32.8	43.7	44.5	20.0	32.2	28.6	49.6	41.5	32.5	34.8	17.1	46.0	24.9	37.9	37.2	29.2	48.1
550	43.7	47.0	56.4	57.7	34.0	46.0	41.7	61.5	55.1	46.3	48.0	30.3	58.1	38.5	50.4	51.4	44.4	57.8
575	53.0	57.0	65.5	67.7	46.0	56.2	51.0	69.0	64.1	56.7	58.2	42.2	66.5	49.5	59.6	61.9	56.1	64.4
600	58.5	62.8	70.9	74.1	54.1	62.0	56.2	72.7	69.2	62.8	64.3	49.5	71.3	56.3	65.6	67.7	62.0	69.0
625	59.8	66.0	73.5	77.7	58.9	64.1	58.4	74.0	70.6	66.2	67.7	53.1	73.2	60.0	68.8	71.3	65.9	73.4
650	59.5	68.3	74.0	79.7	62.0	64.4	59.7	74.0	71.5	67.5	69.0	55.2	73.5	62.5	70.0	72.1	67.7	77.1
675	58.2	69.5	74.1	81.0	64.9	63.8	61.7	72.8	71.0	68.5	68.6	56.2	72.3	64.8	70.7	71.9	68.1	78.8
700	55.7	69.9	72.1	81.9	67.5	62.5	63.2	71.3	70.2	69.0	67.4	57.4	70.5	66.7	71.0	70.9	68.0	81.6
725	52.0	70.4	70.5	82.5	69.1	60.4	64.2	69.3	68.2	68.2	65.8	57.5	68.0	67.8	70.5	—	66.8	82.4
750	48.7	69.7	68.1	82.4	69.6	57.9	64.0	67.2	66.3	66.7	63.5	56.2	65.3	67.7	69.6	—	64.6	—

Data are given in per cent transmission for a thickness of 2mm., except for glass No. 8569 which is a flint glass colored by a silver stain

the percentage transmission, calculations have been made of the transmissions of glass 6621 for various thicknesses. These are plotted in Figure 5.

In Figure 6 are shown the transmission curves of four of the green glasses. A comparison with Figure 9 which shows the transmision curve of a flint glass, indicates at once that there is little difference between the transmission of the flint and the "light green" and "Coca-Cola green." The emerald green, in a thickness of 2 mm., has a more marked absorption, not only in the ultraviolet but throughout the whole spectrum. The effect of increase in thickness, and roughly of increase in concentration, for the emerald green is shown in Figure 7 where transmissions are plotted for five different thicknesses for glass No. 6707.

It will be evident from the foregoing that a wide range in light absorption can be obtained by using glasses that are now made commercially in quantity, and by design of containers to obtain suitable thicknesses of material.

As was indicated in the first few paragraphs of this paper, there is no attempt to point out what glasses, if any, provide any given amount of protection. This can be decided only when data are available on the spectral ranges and intensities of radiant energy that produce given alteration in strength or character of the drugs and chemicals. Work is going forward on this phase of the problem in other laboratories, and when the results are available, it should be possible by reference to the data contained in this paper to select glass of suitable absorption in proper thickness for containers that will provide effective protection to their contents.

TABLE VIII

Spectral Transmission of Blue Container Glass

Wave Length mμ	*6557 Light Blue*	*6618 Light Blue*	*6558 Dark Blue*	*6619 Dark Blue*	*8866 Copper Blue*
289	0	0	—	—	—
297	5.5	0.3	2.4	0.4	—
302	7.3	2.5	9.8	0.4	—
313	28.0	17.0	19.0	10.3	—
334	78.2	72.7	70.8	68.0	49.5
365	89.9	89.0	88.0	88.5	79.9
400	89.9	90.4	88.7	89.2	84.0
425	89.4	89.6	86.7	87.2	86.2
450	88.6	88.5	82.5	81.3	88.6
475	86.1	85.3	71.3	66.9	89.7
500	79.7	78.3	52.3	45.2	88.5
525	71.7	69.0	35.9	27.5	86.2
535	70.7	68.8	34.1	25.5	84.7
540	—	69.3	35.1	26.3	83.5
550	73.2	71.7	39.0	30.6	81.4
560	74.5	72.5	41.0	32.8	78.1
570	—	69.2	36.3	27.8	75.6
575	70.2	66.8	33.0	24.1	73.9
585	—	60.5	26.8	17.0	70.6
590	63.2	—	23.5	14.2	68.9
595	62.6	58.7	20.8	13.6	67.0
600	62.7	58.2	21.0	13.9	65.0
610	—	60.2	22.6	14.2	61.9
625	64.5	60.7	23.5	15.7	56.8
645	63.5	60.0	22.3	14.7	50.4
650	64.0	60.2	22.8	15.2	48.9
675	73.2	71.7	38.4	32.5	42.8
700	86.1	85.5	74.4	70.5	39.5
725	89.8	89.0	—	—	37.0
750	90.1	89.1	—	—	37.8

Data are given in per cent transmission for a thickness of 2.0 mm. The light blue and dark blue glasses are commercial glasses colored by cobalt. Glass No. 8866 is an experimental melting colored by copper.

TABLE VII

Spectral Transmission of Green Container Glasses

Wave Length mμ	*6559 Light Green*	*6560 "Coca Cola" Green*	*6707 Emerald Green*	*6755 Emerald Green*	*6865 Emerald Green*	*7204 Emerald Green*	*8209 Emerald Green*	*8210 Champagne Bll. Green (European)*
289	0	0	—	—	—	—	—	—
297	1.0	0	—	—	—	—	—	—
302	0.7	0	—	—	—	—	—	—
313	9.4	0.6	—	—	—	—	—	—
334	65.8	41.9	61.3	64.7	—	—	—	—
340	—	—	—	—	—	—	52.2	1.3
365	88.2	84.2	83.4	83.8	—	0	84.0	3.1
385	—	—	79.8	80.5	—	—	80.0	9.2
405	89.5	88.0	75.6	—	—	1.4	75.5	25.0
420	89.6	87 1	65.7	63.5	66.2	7.9	65.2	28.0
440	89.8	86.5	54.7	51.8	56.4	9.3	53.0	35.0
460	90.3	87.4	54.4	51.9	56.4	18.0	53.0	44.4
480	90.7	88.3	61.4	58.3	61.9	32.2	59.5	51.2
500	91.1	89.2	70.8	68.1	73.3	48.0	70.0	56.2
520	91.4	89.5	79.0	78.7	80.4	63.2	78.5	58.9
540	91.2	89.7	82.9	82.8	84.1	70.3	82.4	60.5
560	91.2	89.7	82.5	82.3	83.2	71.9	82.0	60.5
580	91.1	89.1	76.9	76.1	78.1	63.4	77.0	58.5
600	90.7	88.1	69.0	67.4	69.5	53.7	67.2	56.5
620	90.7	87.3	60.8	58.9	62.7	44.7	58.5	53.8
640	90.3	86.5	56.9	54.0	58.5	39.5	54.8	50.5
660	90.1	86.1	55.8	52.8	56.6	40.4	53.0	46.5
680	90.0	86.1	58.8	55.2	59.0	44.6	56.8	42.2
700	89.9	86.0	60.2	55.3	61.4	48.4	56.8	39.6
720	89.6	85.9	—	—	67.8	53.2	63.2	36.5
740	89.2	85.4	—	—	71.0	61.9	67.5	31.0
760	—	—	—	—	—	65.3	—	—

Data are for percent transmission for a thickness of 2.0 mm.

Acknowledgements

The glasses on which data are given were furnished by various manufacturers, but identification has, for obvious reasons, been omitted. Thanks are due the manufacturers for their courtesy in furnishing the samples and acknowledgement is due to Mr. T. C. Vaughan, who made most of the measurements, and assisted in other ways in preparation of data. Acknowledgement is due also to Mr. W. E. Loomis and Mr. V. C. Swicker for help on the calculations and in other respects.

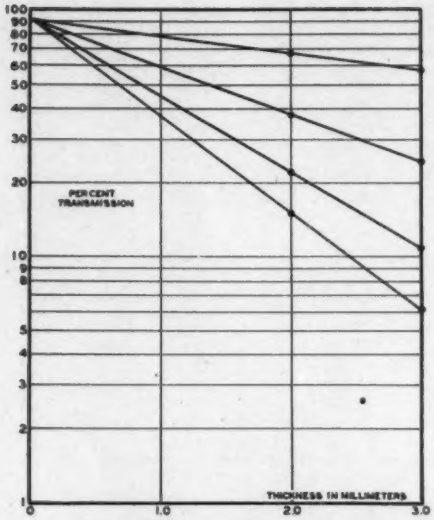


Fig. 1. Graphic methods of transforming transmission figures for various thicknesses of glass.

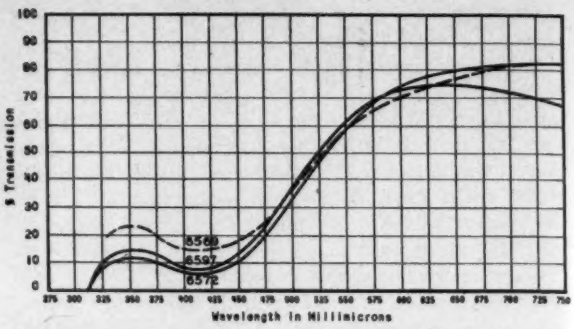


Fig. 2. Spectral transmission curve of typical amber glasses showing approximate minimum and maximum transmissions.

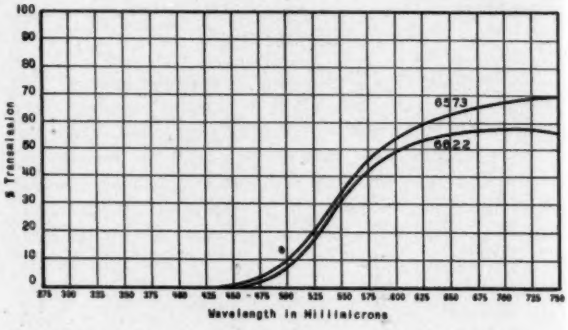


Fig. 3. Spectral transmission curve of typical amber glasses showing approximate minimum and maximum transmissions.

TABLE IX

Spectral Transmission of Flint, Copper Ruby and Heat Absorbing Glasses and of Colored Cellophane

Wave Length mμ	*6575 Flint Milk Bottle*	*8568 Flint*	*8580 Copper Ruby*	*A101 Heat Absorbing*	*A102 Green Cellophane*	*A103 Yellow Cellophane*	*A104 Red Cellophane*
289	0	—	—	—	—	—	—
297	0	—	—	—	—	—	—
302	0	—	—	—	—	—	—
313	5.5	—	—	—	—	—	—
334	56.5	(49.5)	0	56.0	—	—	—
365	84.5	87.6	0.8	77.5	—	—	—
385	88.1	88.0	1.0	80.0	—	—	—
400	88.4	—	—	—	1.7	3.3	—
405	88.4	90.0	1.1	84.2	—	—	—
420	88.3	91.3	4.3	84.2	2.4	2.4	0.5
440	88.0	91.3	4.0	84.8	1.7	8.9	0.3
460	88.0	90.5	3.2	86.2	9.6	10.1	0.2
480	87.7	91.3	4.2	87.0	36.8	15.7	0.2
500	87.5	91.5	5.6	87.0	46.4	39.6	0.1
520	88.0	90.2	6.1	86.5	51.0	71.3	0.1
540	88.8	91.3	6.2	85.6	45.0	83.8	0.1
560	89.6	91.3	6.0	83.8	33.8	88.9	0.1
580	89.9	91.3	15.5	82.0	24.4	90.0	0.9
600	90.0	91.5	37.2	79.4	15.5	90.4	51.7
620	89.8	92.0	52.4	76.0	12.3	91.4	80.1
640	89.7	91.3	59.3	72.5	12.5	90.4	84.3
660	89.5	91.0	64.6	68.5	9.9	89.8	83.7
680	89.5	89.8	66.6	65.0	16.3	90.2	88.6
700	89.4	86.0	70.0	62.5	42.3	85.2	84.6
720	89.2	—	71.0	60.0	—	—	—
740	88.9	—	72.0	47.0	—	—	—

The data are in percent transmission for a thickness of 2 mm. except for the pieces of colored cellophane which were 0.03 mm. thick, and Glass No. 6575, the data on which are given for actual thickness measured, namely 6.7 mm.

Fig. 4. Spectral transmission of two amber glasses roughly representative of the average produced commercially.

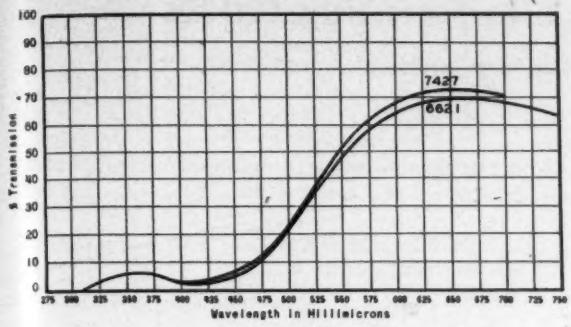


Fig. 5. Effect of thickness on the transmission of amber glass No. 6621.

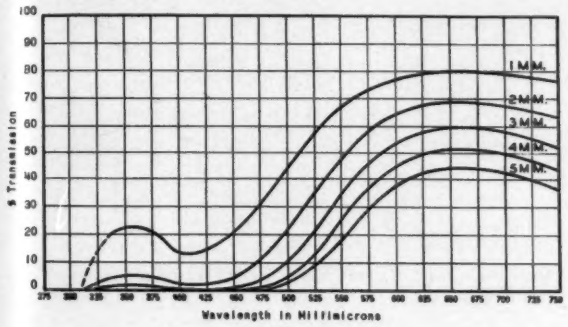


Fig. 6. Spectral transmission curves of four commercial green glasses.

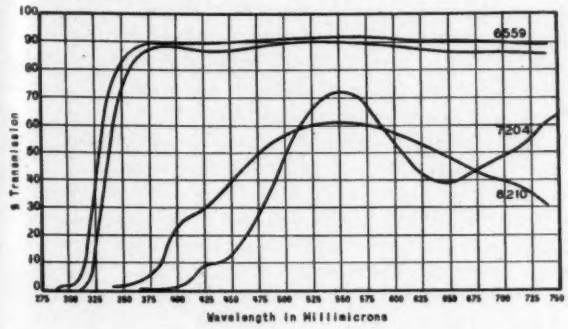


Fig. 7. Effect of thickness on transmission on Emerald green glass No. 6707.

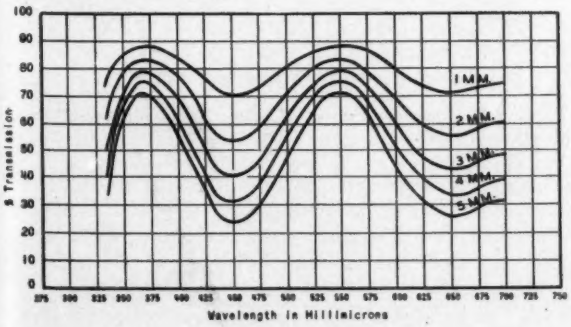


Fig. 8. Spectral transmission of commercial blue glasses No. 6557 (light blue); No. 6558 (dark blue); and laboratory melting No. 8866 (copper blue).

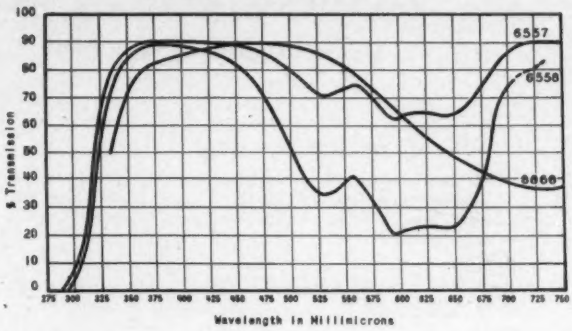
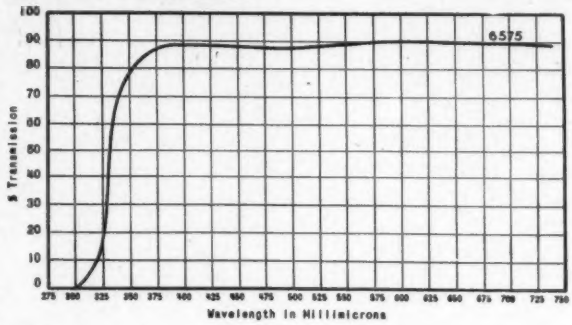


Fig. 9. Spectral transmission curve of a Flint milk bottle glass, 6.7 mm thickness.



[1]The content of this paper is essentially that of a thesis submitted to the New York State College of Ceramics at Alfred University, June 1, 1942, to meet in part the requirements for the Professional Degree of Ceramic Engineer

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CHEMICAL EXPOSITION NOVEMBER 24-29

The National Chemical Exposition, an important contribution by the chemical industry to the wartime effort, will be held November 24 to 29 at the Sherman Hotel, Chicago. The exhibition is sponsored by the Chicago Section of the American Chemical Society. Victor Conquest, director of research for Armour & Company, and chairman of the show committee, reports that the show will be twice as large in number of exhibits and floor space as the first exhibit sponsored by the Chicago Section in 1940. The increased interest is ascribed to the fact that the government is looking to the chemical industry to provide alternates for many critical materials as well as new products which will aid in the present crisis. Information regarding space for exhibits may be obtained from the manager of the exposition, Marcus W. Hinson, c/o National Chemical Exposition, 110 North Franklin Street, Chicago.

HUGH S. BRADY JOINS ARMY

Hugh S. Brady, vice-president and general manager of the Jeannette Glass Company, Jeannette, Pa., has been commissioned as Lieutenant-Colonel in the United States Army. He is attached to the Chemical Warfare Service where he also served in World War I. It is understood that Mr. Brady's former duties will be assumed by his assistant, Joseph Stevenson.

THE DEVELOPMENT OF LOW MELTING GLASSES ON THE BASIS OF STRUCTURAL CONSIDERATIONS

By NORBERT J. KREIDL[1]* and WOLDEMAR A. WEYL*

PART II

EDITOR'S NOTE

In the first instalment the authors discussed the structure of glass and derived five principal changes which lead to better meltability. In this instalment these five principal changes will be discussed.

1. First Structural Change: The Introduction of the Triangular Network of Boric Acid

Hitherto, only one possible continuous structure leading to glass formation has been stressed, the tetrahedral arrangement of oxygen. One other arrangement, namely, a continuity of oxygen triangles around small elements has just been mentioned. Of all the elements which are too small to form a continuous tetrahedral network with oxygen, boron alone satisfies the narrow limits for this triangular arrangement. These limits are given by the geometrical condition that the ratio of the ionic radius of the network forming element to that of oxygen should be not smaller than 0.14 and not larger than 0.225. Only boron with a radius of 0.2 fulfills this condition. The ratio $\frac{\text{radius of } B^{3+}}{\text{radius of } O^{2-}} = \frac{.2}{1.3} = 0.15$ lies between .14 and .225.

B_2O_3 itself indeed forms a low melting glass and it is very difficult to obtain this compound in the crystalline state. Due to its loose triangular structure B_2O_3 shows a high coefficient of expansion. Nevertheless, when added to a silicate glass it definitely lowers its thermal expansion. This phenomenon, known for decades, was a puzzle to the glass technologists. A systematic study of this effect revealed that it ceased and even became reversed when approximately 12-15% of B_2O_3 had been added to an alkali silicate glass. This unexpected behavior had led to the term "boric acid anomaly."

Only recently, an explanation was furnished by Warren's interpretation of the X-ray analysis of borosilicate glasses. According to this interpretation, in the presence of network modifiers a certain amount of boron can take the position of silicon and be surrounded by oxygen tetrahedra in the same way as silicon. In this case the addition of B_2O_3 decreases expansion and melting temperature like silicon although not to the same extent. This difference accounts for the importance of borosilicate glasses of certain compositions, especially since B_2O_3 in any case improves chemical resistivity. As only a certain amount of boron can be accommodated in the silicon position, the exceeding B_2O_3 gives rise to the formation of the weak triangular structure (Fig. 6†) and the melting temperature decreases while the coefficient of expansion rises again.

In addition to the use of B_2O_3 in these borosilicate glasses, use has been made of its fluxing properties in enamels, glazes, vitrifiable colors, and in the pyrex brand glass. In glasses of low alkali content, like in the pyrex brand glass, only the triangular structure can form. Addition of B_2O_3 to pure SiO_2, therefore, lowers the melting temperature and increases the expansion.

2. Second Structural Change: The Variation of the Oxygen Ratio

According to Table V†, the second structural variation influencing meltability is the change of the oxygen ratio. The following two cases where increasing oxygen ratio increases the meltability have already been discussed.

(a) The Addition of Modifiers—The increase of the oxygen ratio by the addition of a so-called modifier is summarized in Table VI [A]:

NWM = Network Modifier NWF = Network Former

	(A)						(B)		
Composition	SiO_2			Na_2O+SiO_2			P_2O_5		
	NWM	NWF	O	NWM	NWF	O	NWM	NWF	O
	–	1	2	2	2	5	–	2	5
Oxygen Ratio			2			2.5			2.5
Ratio $\frac{NWM}{NWF}$ $\frac{Na^+}{Si}$ or $\frac{Na^+}{P}$			0			1			0

Table VI. Sodium disilicate and P_2O_5 oxygen ratio of silicate glasses.

(b) Network formers of high valency: P_2O_5. In this case (Table VI [B]) less alkali was required for the same oxygen ratio.

(c) Network formers of lower valency: Alumina, Boric oxide. In the development of meltable glasses of high resistivity the role of Boron and Aluminum oxide is of particular interest. In their influence on the oxygen ratio these two trivalent elements are equal as long as Boron enters a tetrahedral arrangement.

While the replacement of Si^{4+} by the pentavalent P^{5+} causes a higher oxygen ratio, the replacement of Si^{4+} (or P^{5+}) by the trivalent Al^{3+} in the network causes a decrease of the oxygen ratio so that a strengthened structure results and the melting temperature will be increased. Endell's measurements bear out an increase in viscosity on replacement of Si by Al except for the first fraction of a per cent.

The effect of the increased oxygen ratio will be partly

Soda Lime Glass			Two Silicon Replaced by Al_2		
$Na_2O+CaO+6SiO_2$			$Na_2O+CaO+Al_2O_3+4SiO_2$		
NWM	NWF	Oxygen	NWM	NWF	Oxygen
$2Na,1Ca$	$6Si$	14	$2Na,1Ca$	$2Al,4Si$	13
3	6	14	3	6	13
Oxygen Ratio $\frac{14}{6} = 2\frac{4}{6}$			Oxygen Ratio $= \frac{13}{6} = 2\frac{1}{6}$		

Table VII. Oxygen ratio of silicate glasses containing aluminum.

counteracted by the weaker bond of the trivalent aluminum with its oxygen surrounding. The pure influence of the replacement of silicon by aluminum on the oxygen ratio may be seen from Table VII.

The pure P_2O_5 glass with its oxygen ratio of 2.5 is too weak and unstable like sodium disilicate glass

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*Ceramics Department, Pennsylvania State College.

	NWM	NWF	Oxygen	Ratio	STructure	Oxygen Shared
P_2O_5		2P=2	5	2.5		
$Na_2O+2SiO_2$	2Na	2Si=2	5			3
$Al_2O_3+3P_2O_5$	-	2Al+6P=8	18	2.25	Between 3and 4	
Metaphosphate						
$Na_2O+4SiO_2$	2Na	4Si=4	9			
$Al_2O_3+P_2O_5$	-	2Al+2P=4	8	2.0		4
Orthophosphate						
SiO_2	-	1Si=1	2			

Table VIII. Oxygen ratio of alumophosphate glasses.

($Na_2O.2SiO_2$) with the same oxygen ratio. We can increase the oxygen ratio and strengthen the structure of the sodium disilicate glass by decreasing its Na_2O content. In the pure P_2O_5 glass there is, however, no network modifier present and there seems, at the first moment, no way of obtaining phosphate glasses of a lower oxygen ratio than 2.5.

Now we have just seen that the addition of Al_2O_3 lowers the oxygen ratio of the silicate glasses. In the same way, Al_2O_3 can be used to lower the oxygen ratio of the P_2O_5 glass and to strengthen its structure. If finally one mole Al_2O_3 is added to one mole P_2O_5 the oxygen ratio 2, that is that of SiO_2 is reached and some properties of pure silica can be approached. Certain properties such as the U V-transmission and the electric insulation of silica glass are caused by the absence of alkali. In this respect even the alumophosphate glasse of higher oxygen ratio than 2, which in their melting behavior compare with soda-lime glasses, resemble pure silica because they do not contain any alkali. This can be seen from Table VIII where several steps of Al_2O_3 additions to P_2O_5 are compared with silicate glasses of equal oxygen ratio.

Moreover, the valencies 3 of Al and 5 of P compensate nicely in neighboring oxygen tetrahedra which actually demand central ions of the valency 4.

From the alumophosphate glasses a large number of compositions have been derived by the addition of alkali, zinc, B_2O_3, CaO, BaO, MgO, SrO, and their phosphates and fluorides. Such glasses will always contain less alkali than silicate glasses of the same melting range.

In order to make this fact more evident the oxygen ratios of these glasses can be plotted against their sodium content as in the Figure 5† (Fig. 7). In addition to sodium phosphate and sodium silicate glasses we can now include alumophosphate and sodium alumophosphate glasses in the comparison; if the dotted lines on the Figure 7 are studied, it becomes apparent that an alumophosphate glass contains much less sodium and is, therefore, expected to be more resistive and to possess better insulation properties than silicate glasses of the same oxygen ratio and similar melting behavior.

On Table IX these alumophosphate glasses of Figure 7 are compared with silicate glasses of equal oxygen ratio with respect to their Na^+ concentration per glass forming tetrahedron, that is, per Si or P. These comparisons correspond to the dotted lines on Figure 7.

In all composition ranges, where boron takes the place in an oxygen tetrahedron, for instance; if about 15% B_2O_3 is added to alkali containing glasses B_2O_3 and Al_2O_3 act similarly. The melting temperature of the glasses are usually lower and combinations of B_2O_3 and Al_2O_3 are particularly useful in laboratory ware. The field of resistive phosphate glasses, especially those of low softening point, can be considerably widened by the simultaneous use of B_2O_3 and Al_2O_3.

Even by a divalent ion, for instance, Zn^{2+} taking the place of the network former, the oxygen ratio of a sodium silicate or phosphate glass may be decreased similarly. ZnO forms another important constituent of lower melting glasses. Zn has a specific action on chemical resistivity similar to that of aluminum. Both are constituents of very low melting glasses of reasonable resistance to water.

3: Third Structural Change: Exchange of the Glass Former

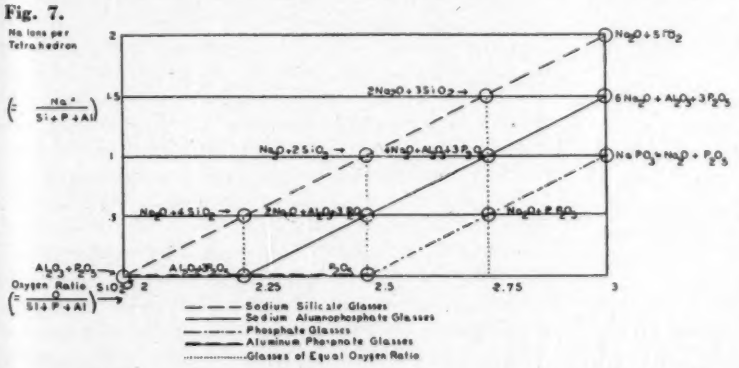
In Table IV some elements were listed, which may partially be substituted for silicon in its network forming position, although they do not completely fulfill the requirements of a network former.

As a first approximation, it may be said that such a substitute network former will weaken the glass, if the ratio valency is smaller than that of silicon. Consequently such a substitution represents a third principle of developing softer glasses. This ratio is smaller, if either the valency is smaller than 4 or, if the size of the ion is larger than that of Si. If the valency is lower, (Al^{+++} for Si^{++++}) we have seen that the weakening effect is frequently more than compensated by the strengthening effect of the decreased oxygen ratio.

Substitution by a tetravalent element of larger size will be more effective. An example is the effect of TiO_2.

Introducing TiO_2 has the advantage that the weakening of the structure again does not involve an increase of the

Fig. 7.



Oxygen Ratio →	2		2.25		2.5		2.75		3	
Silicate Glasses	Composition SiO_2	Na+ per Tetrahedron	Composition $4SiO_2+Na_2O$	Na+ per Tetrahedron	Composition $2SiO_2+Na_2O$	Na+ per Tetrahedron	Composition $4SiO_2+3Na_2O$	Na+ per Tetrahedron	Composition SiO_2+Na_2O	Na+ per Tetrahedron
	Na Si O	0	Na Si O	½	Na Si O	1	Na Si O	1.5	Na Si O	2
	- 1 2		2 4 9		2 2 5		6 4 11		2 1 3	
Alumophosphate Glasses	$Al_2O_3+3P_2O_5$	0	$Al_2O_3+3P_2O_5$	0	$Al_2O_3+Na_2O+3P_2O_5$	½	$Al_2O_3+Na_2O+3P_2O_5$	1	$Al_2O_3+Na_2O+3P_2O_5$	1.5
	Na Al P O		Na Al P O		Na Al P O		Na Al P O		Na Al P O	
	- 4 6		- 8 18		4 8 20		8 8 22		12 8 24	
Phosphate Glasses	—	—	—	—	P_2O_5	0	$2P_2O_5+Na_2O$	½	$P_2O_5+Na_2O$	1
					Na P O		Na P O		Na P O	
					- 2 5		2 4 11		2 2 6	

Fig. 7. (left above) Sodium content of various glasses of equal oxygen ratio.

Table IX. (left) Alkali content of various glasses of equal oxygen ratio.

alkaline constituents. The use of TiO_2 as a flux has become important in the manufacture of low melting vitrifiable colors, which are used for resistive ceramic labels on milk bottles, gasoline signs, and similarly exposed glassware.

Related in scope seems the action of lead oxide in silicate glasses. There can be no doubt that the lead ion when introduced into a soda-lime glass assumes places similar to calcium. In high concentrations, however, lead might even act as if it were participating in the network formation and, therefore, replace a SiO_4 tetrahedron. We have different reasons why such a double role of the lead ion can be expected. The electronic structure of the lead ion is so different from that of the network modifiers and its polarizing action so strong, that it would be unfair to compare it with other ions only on the basis of the apparent ionic radius. Another more striking reason for assuming the participation of ions in the structural units of high lead glasses is the very fact that lead orthosilicate like zinc orthosilicate can be obtained in the vitreous state which would be impossible if all lead or zinc ions would only assume modifying "hole" positions.

A lead orthosilicate glass 2 $PbO.SiO_2$ from a chemical view point, accordingly, cannot be considered as the lead salt of silicic acid but rather as the lead salt of a plumbosilicic acid. Pure orthosalts of SiO_2, with their oxygen ratio of 4, cannot form glasses as the $Si\text{-}O_4$ units would be isolated and not interlinked by any shared oxygens.

Recently Kuan Han Sun tried to give a different explanation for the puzzling fact that a 2 $PbO.SiO_2$ glass exists at an apparent oxygen ratio of 4. He introduces the idea that a part of the silicon possesses hexafold coordination. Units of hexafold coordination would resemble octahedra which do not possess sufficient flexibility to allow assymetric interlinkage. Glasses consisting of octahedral units have never been observed for, if preent, these units would immediately form centers of crystallization. The presence of a small part of the silicon in six-fold coordination was never proven experimentally. But if a part of the silicon would be present in six-fold coordination it could not be considered a network forming ion any more. Consequently, the oxygen ratio calculated on this assumption of Sun would even rise above 4, the contrary of what we would expect in a stable glass.

4. Fourth Structural Change: The Effect of the Modifiers

In order to simplify the discussion of any variation of the oxygen ratio and the network forming ions we have, hitherto, assumed that the only modifying constituent present was sodium oxide. Nonparticipation in the network, however, making its oxygen available for the structure proper, is not a unique property of the sodium oxide. All the monovalent alkali ions and many other ions exhibit this feature because in the melt they cannot compete successfully with the tetravalent silicon for an oxygen neighborhood.

The effect of the various network modifiers, for instance, Na^+, K^+, Li^+, Cs^+ Rb^+, Ca^{2+}, Mg^{2+}, Ba^{2+}, Sr^{2+} is obviously not identical. Therefore, we can influence the meltability by the proper selection of the modifying ions, too. These variations have been used for a long time by the practical glass maker.

(a) The Size of The Alkali Ions—The replacement of an alkali ion by another of smaller size results in a glass of lower viscosity. Thus, the substitution of Na^+ for K^+, or Li^+ for Na^+ or K^+, decreases the viscosity and the melting temperature. It is important not to confuse this effect with the true melting points of crystalline silicates, since lithium metasilicate and lithium disilicate melt at higher temperatures than the corresponding sodium silicates. This rule of size is valid in the area of most silicate glasses of commercial importance, but the application of lithium is limited by its tendency to cause the glass to devitrify.

The explanation of the effect of the ion of smaller size is found in the more pronounced weakening of the bonds of the $Si\text{-}O_4$ tetrahedra by the close neighborhood of an ion of higher positive potential (Table X).

	Cs	Rb	K	Na	Li
Valency	1	1	1	1	1
Ionic Radius	1.75	1.5	1.33	1	0.75
Potential = Valency / Ionic Radius	0.57	0.66	0.75	1	1.33

Table X. Ionic potential of network modifiers.

(b) The Concentration of Alkali Ions—With increasing concentration the relative weakening action of an alkali ion of higher potential becomes less and less effective. At around 20% Na_2O or Li_2O, melts of the silicates approach identical viscosities and melts of still higher alkali concentration exhibit even the reverse phenomenon. Very basic lithia melts are more viscous than the corresponding sodium melts. Now the high potential of the smaller ion becomes manifest by the stronger Li-O bond, while the disturbing effect on the $Si\text{-}O_4$ tetrahedra becomes less and less apparent, the lower the SiO_2 concentration becomes. Here we are not primarily interested in this phenomenon since these basic composition ranges are beyond the usual composition of glasses and more pertinent to slag problems.

(c) Complexity—Even though at low concentrations the smaller alkali ions decrease the melting range more than the larger ones, a mixture of two alkali oxides is known to be more effective than either one. Sodium potassium glasses and sodium lithium glasses are easier to melt than the pure sodium or lithium glasses from which they are derived. This phenomenon is known to the practical ceramist, especially to the enamelist who considers the complexity of his batch as a pre-requisite for both good meltability and good properties.

The well known effects of eutectics on the liquidus curves of polynary systems are by no means identical and comparable with the low meltability of the glasses. The softening effect caused by complexity frequently exists only at lower temperatures and higher viscosities, or at least is more pronounced below the working temperature. In this case the range is wider, corresponding to a "sweet" glass. In enamels and vitrifiable colors a wide firing range may be desirable in addition to the low firing temperature.

The increase of the firing range of the glaze, or the sweetness of the glass is a consequence of the presence of a greater variety of bonds. Indeed, pure silica or aluminum and zinc phosphate glasses, which contain

(*Continued on page* 402)

Research Digest

Practical Interpretations of Glass Technology

The Influence of Temperature on the Mechanical Properties of Glass

In the field of metals one of the important and much investigated subjects is that which concerns the effect of temperature on mechanical strength. If glass is to compete with metals in the structural engineering field or is to be offered as a substitute for metals its temperature-load limitations must also be known. Jones and Turner (Jour. Soc. Glass Tech., February, 1942) have investigated this subject and their results are a worthy addition to the all too meager information in glass literature.

The main difficulty in this type of testing is the wide variation in strength values that are obtained, such variations being due to variations in the condition of the glass surface. Jones and Turner overcome this difficulty by using a large number ($n = 100$) of test pieces and by treating the results so obtained statistically. This procedure allows one to determine whether the differences in strength values obtained under different sets of conditions are significant or whether they are merely attributable to chance. In their work on the variation of the modulus of rupture with temperature the data is presented in the form of two statistics; the arithmetical mean value of the modulus and the coefficient of variation (while this latter statistic is nothing more than the standard deviation in percentage; $v = \frac{100\sigma}{\bar{x}}$, it may have given a clearer picture of the distribution spread if the standard deviation had been used instead of the coefficient of variation).

The modulus of rupture studies indicated that the strength of glass in the form of laths 0.5 cm. wide and of effective length, 5 cm, and having ground and polished sides and fire-polished edges, was not affected by temperature until a temperature of about 480° C was reached. Above this temperature the strength rapidly declined. In the second part of the investigation the variation with temperature of the endurance under load was studied and it was found that at the higher temperatures (to 480° C) the test pieces sustained the load for longer periods before breaking.

While the results of this work indicates that glass suffers no serious loss in strength at elevated temperatures up to 480° C it must be remembered that the test pieces used represent ideal surfaces and as such are far removed from glass as it exists in its many commercial forms. The influence of surface condition on strength still remains the principle problem when glass is being considered as a material of construction. Also, for use in applications at elevated temperatures above 480° C the limitation on glass is not one of strength but is its decrease in rigidity under load.

Effect of Storage Conditions on Weathering of Commercial Glass Containers

Chemical durability, that much investigated property of glass, again makes the pages of the current glass literature. This time, Owens and Emanuel (Jour. American Ceramic Society, September, 1942) take up the weathering phase of this subject and have reported on the results of an investigation on the influence of chemical composition, humidity, temperature and capping on this phenomena. Using 8 oz. containers of two different compositions and 4 oz. containers of eight different compositions as their samples the authors stored them, both capped and uncapped for periods up to 13 months at (1) 100°F., 80 per cent relative humidity, (2) 120°F., 15 per cent relative humidity and (3) normal room conditions. At various time intervals samples were examined, the degree of weathering measured visually, and the alkali extraction value measured by chemical means.

From the results obtained it was concluded that (1) the atmospheric humidity is the most important factor in the development of weathering and (2) although the weathering produced depends upon several factors such as chemical composition, the use of a closure during storage, and the length, temperature and humidity of storage, the degree of weathering can be significantly controlled by the chemical composition of the glass.

To those who manufacture the type of container that requires capping at the lehr (prescription ware) that part of this investigation which deals with the effect of capping on weathering is of direct interest. This phase of the subject may be summed up as follows: in general (except for a few compositions) after storage for 12 to 13 months at the high humidity condition the uncapped containers showed more visible weathering than the capped containers while the chemical durability of the capped containers was lower (greater alkali release) than that of the uncapped containers. In the case of the tests at the lower humidity and at normal storage conditions capping had no appreciable effect on either the visible weathering or on the chemical durability. In this connection it would have been of practical interest if the authors had been able to duplicate the condition where warm containers coming off the lehr are capped under various humidity conditions. Such conditions are known to exist in practice and have been found to be responsible in part for mold growth on the composition cork liners sometimes used in the closures. How much this so-called "capped in humidity" effects the chemical durability of the container is not known.

New Methods of Cleaning Glass Sands

While there is no shortage of glass sand, and none seems to be on the way, the uncertain and critical situation in regard to railroad shipments has made it necessary for many of those glass plants which are dependent upon sources of supply far distant to investigate the possibility of using local sand deposits in cases of emergency. Those interested in the local sand subject would do well to look up the paper on "New Methods of Cleaning Glass Sand" by Dasher and Ralston (Jour. American Ceramic Society, June 1941) and re-read it.

While the authors are primarily interested in describing the "attrition scrubber" method of lowering the iron

(*Continued on page* 400)

BRITISH GLASS TURNS TO SIMPLICITY OF DESIGN

Rationalization of production methods and problems of fuel and raw materials are under study by the recently formed Consultative Council, representative of the National Glass Manufacturers' Association, the National Flint Glass Makers' Society, and the National Association of Glass Cutters and Decorators. Labor shortage, doubling of the tax on cut glass, and the prime need of adhering to expanding Services contracts are the major issues which must be untangled.

The labor shortage, a condition which must be accepted, has necessitated drastic simplification of design and execution throughout all stages of manufacture. Hundreds of Britain's most expert designer-technicians, cutters and engravers have joined the forces and decorative elaboration is necessarily "out." However, simplification of design has definite advantages, and among others it will force an acceptance of the modern functional ideas on some factories which are inclined to an old-fashioned taste for "fussy" design. And simplicity does not necessarily connote severity or ugliness.

Stoubridge is now turning out utility products of great charm in tumblers, decanters and fruit sets. With a view to the United States market, interest is being centered on hand-blown and hand-cut finger bowls and liqueur glasses reminiscent of the best Scandinavian products. Another line, in high quality English crystal, accents the patriotic and allied effort, including a lager-beer set with an R.A.F. motive—"Never have so many owed so much to so few," and a Navy touch in a whiskey bottle, beer mug and capstan ash tray set.

Pressed glass makers are working at peak pressure and cannot keep up with all demands, home and export.

MINERAL INDUSTRIES BUILDING DEDICATION AT WEST VIRGINIA UNIVERSITY

Fully completed and equipped, the new million dollar Mineral Industries Building will be dedicated on October 16th at the opening of the 76th academic year of West Virginia University. The building is considered by competent authorities to be the finest structure of its kind in this country. It houses the School of Mines, the West Virginia Geological Survey, the Department of Geology, and the Department of Chemical, Metallurgical, and Ceramic Engineering.

Dr. Friend E. Clark, chairman of the University Graduate Council and head of the Department of Chemistry, has announced a two day program at which speakers of national and State-wide reputation will appear, including Governor M. M. Neely and President Charles E. Lawall of the University.

ENGINEERING EXPOSITION TRANSFERRED TO MADISON SQUARE GARDEN

The Exposition of Power and Mechanical Engineering, originally scheduled to be held in Grand Central Palace, has been transferred to Madison Square Garden due to the taking over of the Palace by the U. S. Army as an induction center. The Exposition, of which Charles F. Roth is manager, will be staged from November 30th to December 4th. Particulars regarding space may be obtained at headquarters, 480 Lexington Ave., New York.

JOHN C. MAGNESS

John C. Magness, long associated with the Glass Container Association as Director of the Traffic Division, and highly respected as a man of unusual ability and integrity, died on September 13th at his home in Great Neck, Long Island.

Mr. Magness was made assistant to the director of the Traffic Division, John T. Hendricks, in 1923, two years after the formation of the division. Upon the resignation of Mr. Hendricks in 1926 he was chosen to succeed to the position of Director and continued in that capacity until the time of his death.

Mr. Magness was well fitted to deal with problems of traffic through his early experience in railroad, industrial and commercial lines. Associated with the C. H. & D. Railway (later a part of the B & O system) he served in practically every branch of the freight department and for eight years was head of the rate department. Giving up his railroad career he entered the lumber business, and later the marketing of automobile specialties. In both of these enterprises, as a partner, he was in active charge of promotion and sales. His outstanding achievement in the glass container field was the establishment through the Interstate Commerce Commission, in 1933, of a complete parity on transport charges for glass packed products with the same type of products packed in tin. This was one of the most constructive steps in the glass packaging industries and an issue of over forty years standing.

Among the clubs of which Mr. Magness was a member are: Shippers' Conference of Greater New York; Traffic Club of New York; National Industrial Traffic League. He was a Past Master of Masons, Cincinnati lodge.

• The Columbia Chemical Division of the Pittsburgh Plate Glass Co. has moved its executive sales office, triffic and advertising departments, from New York to Pittsburgh. Mr. W. I. Galliher will be in charge of sales activities.

• The Ransome Concrete Machinery Company, Dunellen, N. J., has changed its name to the Ransome Machinery Company and will continue to manufacture the same products with which it has been identified in the past. No changes in personnel have been made.

INCREASING EFFICIENCY IN WARTIME PURCHASING

By ERNEST W. FAIR

With a great percentage of each glass plant executive's outgoing dollar being spent on supplies, materials and equipment, his purchasing operations are of importance at all times. But during wartime, as all costs increase and the opportunities for errors occur again and again, purchasing requires even more care and attention than ever before.

In the case of smaller plants where purchasing is the direct responsibility of the boss himself, in addition to his many score other duties, the opportunities for mistakes are even greater in wartime. Then as never before, he must make every purchase with the utmost care.

In the paragraphs to follow are suggestions we have gathered from the advice of a number of successful executives who are giving this problem close and thorough study.

The first and foremost rule recommended time and again is that nothing should be purchased in wartime unless it can do its specific job more efficiently and more economically. There is no longer opportunity for application of the trial and error method of trying "a little" or "awhile" for our wartime profit margin is growing slimmer and slimmer, approaching so near the dangerous figure that we cannot afford a single experiment. The first wartime purchasing rule is that the item or ingredient must have a specific problem to do, it must be known to be able to do its job, and we must be sure that this can be done. Efficiency and economy are two watchwords on every purchase, none excepted from supplies to equipment.

Secondly, supplies and materials must be purchased on a basis of trade name and reputation of the manufacturer. In the past many brands have been foistered on glass industry executives which failed in performance—merchandise upon which claims made were misrepresented and distorted. We could sometimes take a chance on such merchandise for reasons of our own, but today we cannot afford to take a chance. No matter how enticing the item offered may be, it should be shunned unless well known from personal experience, attest of other executives, and trade journal promotion.

It is far better to continue using a supply item with which we have had considerable experience if we know that item to be adequately performing its job in our plant operation, even though we may hear glowing tales of the superior merits of some other item along the same lines.

We can't take chances in wartime!

Another pointer of importance in wartime purchasing is that of specifications. Not having proper specifications when buying is as foolish as buying an unknown, untested item. Just buying "any good oil," for example when one of a certain viscosity or flash test is the one and specific oil we need for lubrication of a particular piece of equipment is not only a good way to waste money but to invite equipment breakdown. And equipment breakdown in wartime may mean "breakdown for the duration" as parts and equipment itself become more and more difficult to replace.

"Give as much care to specifications on such items as you do to making out a tax report," is one executive's advice, "Don't take chances and don't order just anything because you think it is good.

"Find out the exact need of the supply item you are purchasing; get your specifications to the minutest detail. Doing that will help you avoid loopholes through which an unscrupulous supplier may sell you something inferior.

"Be sure your specifications accurately describe the item specified and the physical or performance requirements that must be met. And see that any such specifications are worded simply; that makes sure no misunderstanding can exist on either your part or on the part of the other fellow."

Next in importance is assurance that the items will be on hand for use when the time comes for their use. Waiting to order until one is down "at the bottom of the bin" is extremely risky in wartime. No matter how much ones supplier may be interested in getting that new order to one before the supply gives out, wartime transportation problems may make it difficult for him to do so.

The result is that more and more executives are "ordering earlier." There is no set rule that can be followed everywhere but orders should be placed as early as possible and more than ample time allowed for delivery.

"Have supplies enough to run for eight weeks when you order," is another executive's advice. "Unless such items are of a scarce nature in which case allow an additional eight weeks. When your stock of the specific item is down to an eight or sixteen week supply then is the time to re-order. And when you re-order place it for IMMEDIATE DELIVERY, not delivery in eight or sixteen weeks. The problem isn't so much the supply firms' desire to deliver as it is their ability to deliver at the time specified."

The only safe rule an executive can follow in wartime is to never permit supplies of any kind to get "too low" and to reorder for immediate instead of future delivery whenever possible to do so.

The urgencies of the times also call for more strict record keeping on supplies. No matter how small one's plant, every executive should have a supply record book atop his desk all of the time and therein should be kept a day-to-day record of the amount in stock of each and every item he needs. Each page should have penciled in red the figure at which re-order should be made; the figure showing an eight to sixteen weeks supply on hand.

INVENTIONS AND INVENTORS

A Summary of United States Patents of Interest to the Glass Industry Issued During August

Compositions:

Frank J. Dobrovolny of Ransomville, N. Y. (E. I. du Pont de Nemours & Co.) who was granted a patent last year (2,230,199) for ruby and opal glass in which sodium oxide was used to replace soda ash, now proposes in patent 2,294,077 to use a similar substitution in clear optical glass. An improvement in fining characteristics is claimed.

Furnaces:

Another patent on electrically heated melting tanks has been added to the important group held by Societe Anonyme des Manufactures des Glaces & Produits Chimiques de Saint-Gobain, Chauny & Cirey, Paris, France. It will be recalled that many of these have issued to Edouard V. Borel. The latest patent 2,293,948 was granted to his associate Yvan Peyches also of Paris. As shown in Fig. 1 the movement of the glass to the fining

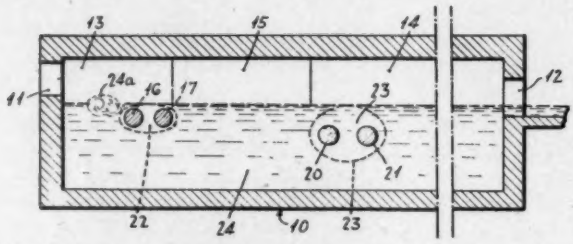


Fig. 1. 2,293,948: Peyches. In an electric tank furnace the electrode pairs at the left are closest together and to the surface to give the greatest heat intensity in the melting end.

end of the tank at the right requires that it pass pairs of electrodes both in the melting and fining sections. The pair of electrodes 16-17 in the melting end, extend across the tank, and to provide a very hot zone are intentionally placed close together and quite close to the surface. This provides the highest temperature where it is most needed. The electrodes 20-21 in the fining end are farther apart and farther below the surface.

P. K. Devers of Lynn, Mass. (General Electric Co.) received patent 2,292,826 for a silica fusing furnace. He states that in previous furnaces such as the one described in his patent 1,826,358 air bubbles are avoided by melting in a vacuum, but that the contact of the silica glass with the carbon resistors results in slight stria or other optical imperfections. Such glass, used in vapor discharge lamps, fails at high temperatures due to devitrification. Devers has now found that these blemishes are largely eliminated by carrying out the fusion in a refractory container of zirconia or beryllia. His apparatus removes the carbon electrodes from the zone of fusion by placing them outside the crucible, packed in granular refractories of the same type as the crucible.

Feeding, Forming and Shaping:

A new method of gathering glass by suction methods is described in patent 2,292,370 issued to Enoch T. Ferngren of Little Neck, Long Island, N. Y. As in so many of the patents bearing on feeding methods, the objects include the minimizing of shear marks and the removal of the chilled glass from the path of subsequent charges. The charges are drawn from a stationary pool through a gathering mechanism into the blank mold above it, each succeeding unit doing the contacting at the same point of the pool, and so designed as to grip all of the surplus glass touched by the mechanism and to move it as a unit body away from the point of contact; subsequently the chilled portion of glass is released from each gathering unit at a predetermined point of the pool to build up at that point a slowly sinking body of accumulated chilled portions.

Fig. 2 from patent 2,293,860 issued to Carl T. Sloan of Jeannette, Pa. (The Jeannette Glass Co.) shows a feeding mechanism which is said to produce a reshaping of the gob which buries the shear mark. In the illustration the hexagonal object 28 is a projector which receives the charges and throws them to the left against a guide 29 which modifies their form and directs them into a mold 5 at such an angle as to alter entirely the position of the shear mark relative to the shape of the charge. The shearing method is also novel since the glass is allowed to flow from the forehearth and to rest upon the upper surface of the projector before it is sheered.

Patent 2,292,048 granted to Robert W. Canfield and Thomas Waugh of West Hartford, Conn. (Hartford-Empire Co.) concerns a method of forming bottles which

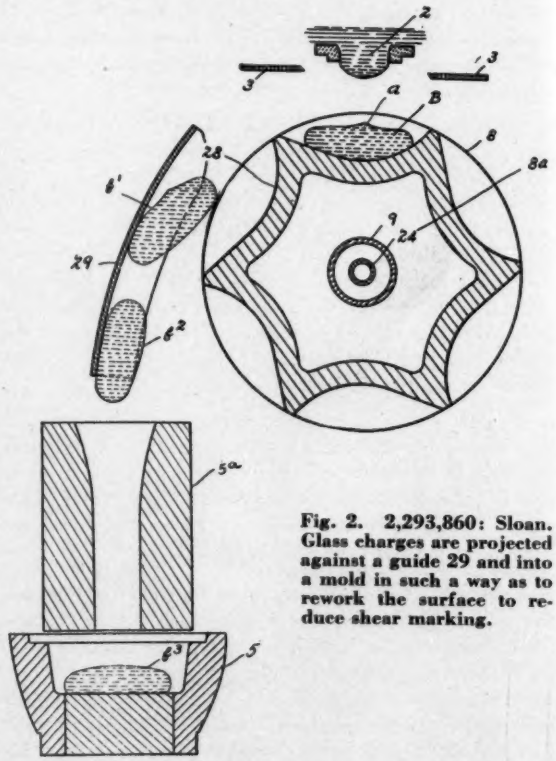


Fig. 2. 2,293,860: Sloan. Glass charges are projected against a guide 29 and into a mold in such a way as to rework the surface to reduce shear marking.

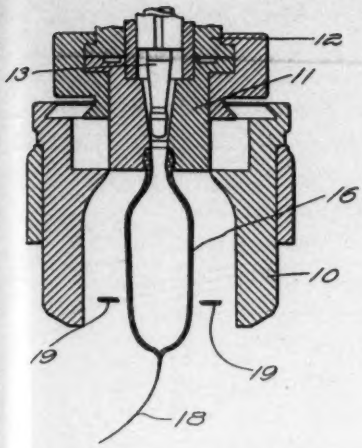


Fig. 3. 2,292,048: Canfield and Waugh. An extra-length parison is sheared after initial shaping and is then reheated within the mold before the mold walls are again closed to allow final blowing against a bottom plate.

comprises gathering a glass charge in a neck mold and a partable body mold by suction from a pool, expelling sufficient glass from the interior of the gathered charge to leave a hollow glass body, opening the body mold, cutting through the hollow glass body or parison (Fig. 3) to shorten it, closing the bottom mold and then blowing against a bottom plate to form the final article.

Miscellaneous Processes:

A lens grinding machine is described in patent 2,293,291 assigned by Joseph Gasperi of New York to J. Gasperi & Co. Inc.

In making a dual-thickness window pane in which the two plates are soldered together by a lead spacer strip, Charles D. Haven of Toledo has found (patent 2,293,822, Libbey-Owens-Ford Glass Co.) that a sprayed coating of a copper-titanium alloy applied to the glass facilitates soldering. The metal is substantially all copper except for 0.5 to 4.5 per cent titanium.

A coupling for connecting the ends of two sections of glass pipe is described in patent 2,294,160 issued to Leonard G. Crane of Oneonta and Harold J. Tillson of Morris, N. Y.

In patent 2,292,684 assigned to Corning Glass Works by Henry H. Blau, a glass article capable of becoming opacified by heat treatment, is differentially opacified by applying to selected areas which are to remain clear a heat insulating material bonded with a soluble salt which will not fuse at the opacification temperature and which can be washed off following the heat treatment.

Plate and Sheet Glass

One of Pete Magrini's patents for overcoming batter or waviness in vertically drawn window glass by providing a transverse circulation of preheated air just above the meniscus was mentioned in the August 1941 GLASS INDUSTRY (patent 2,246,053). A further development in this process research, carried on by the American Window Glass Co., is represented by patent 2,293,377 which has issued to Charles F. Wood of Jeannette, Pa. The improvement consists in releasing the transversely moving air from a multiplicity of small parallel tubes on both sides of the glass sheet.

In making tempered glass sheets, Edoardo Ferlito of Milan, Italy (2,293,537) proposes the system illustrated by Fig. 4. To solve the problem of cutting a tempered sheet without destroying it by the shattering produced by strain release, he proposes to groove both sides of the sheet from edge to edge by stamping rollers e, f and e', f'.

Tempering is produced by air blast from jets on several sets of rolls, and it is reported that the sheet can subsequently be severed at the grooves and the severed edges polished.

Patent 2,293,858 (Conrad B. Schafer, Toledo; Libbey-Owens-Ford Glass Co.) describes a machine for washing bent or curved sheets which are to be used in the manufacture of safety glass.

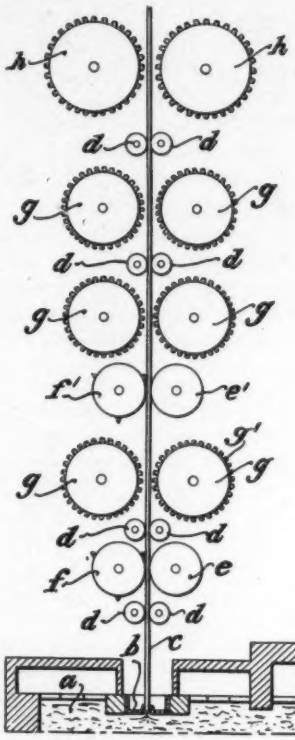


Fig. 4. 2,293,537: Ferlito. A continuous sheet is grooved at e, f to give a reduced thickness along which it may be severed without shattering after tempering by air supply G.

Glass Wool and Fiber:

Those who were interested in the late Charles L. Norton's patent 2,265,742 for producing fibers by the electrostatic dispersal of threads from a charged stream of glass (February 1942 GLASS INDUSTRY) will want to see his latest patent 2,293,165 on the same subject. However, it is illustrated with regard to fibers of cellulose acetate and without reference to glass.

A melting furnace for making glass or mineral wool fibers is described in patent 2,294,266 issued to Randolph H. Barnard of Toledo. The single claim allowed by the patent office is largely concerned with a pressure lock through which a uniform supply of glass is provided to the furnace without disturbing the positive pressure maintained above the glass for the purpose of causing it to flow through the apertures which form the fibers.

Patent 2,293,677 issued to Games Slayter of Newark, Ohio (Owens-Corning Fiberglas Corp.) provides an electrical cable covering in which the outer covering s a coated layer of alkali-free glass yarn.

CURRENT STATISTICAL POSITION OF GLASS

During August activity in the glass industry showed a small rise over the previous month in production, payrolls, and employment. According to THE GLASS INDUSTRY Production Index, output during August was $39,000,000, bringing the January-August cumulative total to $289,000,000 as compared to $297,000,000 in the corresponding period of 1941. The total for August 1941 was $41,000,000.

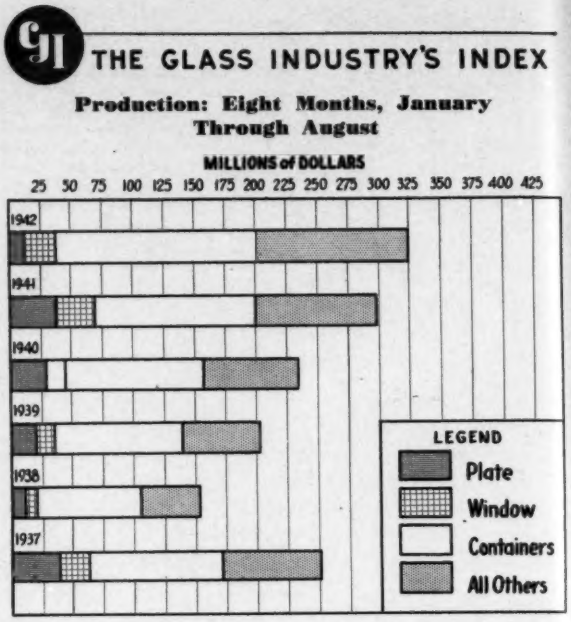
Plate glass production during August totalled 3,862,969 square feet, according to the Plate Glass Manufacturers of America. This represented a decline of 9 per cent from the previous month and 73 per cent less than the total for August 1941. The total production during the first eight months of 1942 was 42,971,063 or 68 per cent less than last year's corresponding period.

Window glass production for the month of August was 1,075,343 boxes which represented 66.2 per cent of the industry's rated capacity. As compared with this, production for August 1941 was 1,267,472 or 78.1 per cent of capacity. The cumulative total for the January-August period was reported at 11,451,343 or 5 per cent greater than for the same period in 1941.

Glass container production during August amounted to 6,584,857 gross, according to the Glass Container Association of America. This represented a decline from the previous month of 10 per cent, and of 4 per cent from August 1941. During the first eight months of 1942 a total of 52,516,456 gross were produced, or an increase of 15 per cent.

Shipments of glass containers during August amounted to 6,901,541 gross which was 9 per cent above the figure for July 1942 and slightly above the total for August 1941. The outstanding gains over 1941's corresponding month were: fruit jars—up 74 per cent; beer bottles—up 72 per cent; wide-mouth food containers—up 39 per cent; liquor ware—up 30 per cent. A decrease was reported in narrow neck food containers of 41 per cent; domestic jelly glasses—36 per cent; medicinal and toilet ware—32 per cent; pressure and non-pressure ware 32 per cent; general purpose ware—21 per cent; pressed food ware—16 per cent; and milk bottles—11 per cent.

During the first 8 months of this year shipments increased 15 per cent over last year to 52,516,456 gross. All lines, with the exception of pressure and non-pressure ware participated in these gains. The largest increases reported were: beer bottles—110 per cent; domestic fruit jars—45 per cent; wide mouth food containers—26 per cent. Gains in other lines ranged from 1 to 10 per cent.



Inventories of glass containers in the hands of manufacturers at the end of August totalled 9,138,549 gross, or 14 per cent higher than on last year's corresponding date. Stocks of all types of ware other than domestic jelly glasses, beer bottles, pressure and non-pressure ware, and narrow neck and pressed food ware containers, were increased.

Miscellaneous glass products manufactured in August were valued at $15,000,000; this compared with $14,000,000 in August 1941. During the first eight months of 1942 production in this branch of the industry totalled

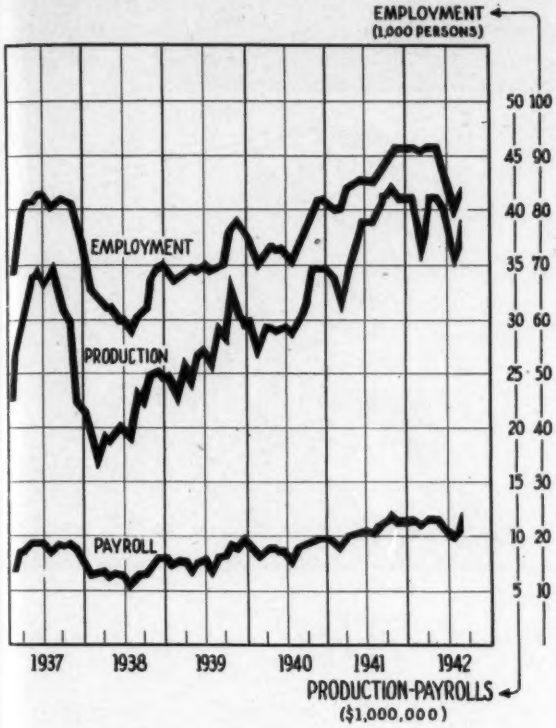
CURRENT GLASS CONTAINER STATISTICS

(ALL FIGURES ARE IN GROSS)

Classifications	*Production*		*Shipments*		*End of Month Stocks*	
	Aug. 1942	*Aug. 1941*	*Aug. 1942*	*Aug. 1941*	*Aug. 1942*	*Aug. 1941*
Food Containers (Narrow neck, wide mouth, and pressed)	2,481,441	2.360,155	2,406,214	2,213,810	2,582,586	2,097,084
Pressure and Non-Pressure Ware	294,362	468,755	320,206	479,139	353,442	445,363
Beer Bottles	666,373	394,395	727,818	432,005	345,475	582,558
Liquor Ware	1,181,873	941,531	1,164,388	924,657	1,453,248	1,347,186
Medicinal and Toilet Ware	1,178,653	1,749,397	1,252,682	1,820,096	3,142,799	2,548,637
General Purpose	293,348	415,034	329,396	413,729	567,812	465,230
Milk Bottles	285,558	315,833	270,169	301,653	363,276	307,410
Fruit and Jelly	174,343	171,249	400,656	239,007	293,342	214,993
All Other	28,906	27,757	30,012	22,646	36,569	43,498
Total Industry	6,584,857	6,844,106	6,901,541	6,846,742	9,138,549	8,051,959

THE GLASS INDUSTRY'S INDEX

Monthly Trends Through August, 1942



121,000,000 as compared to $98,000,000 last year, or an increase of 18 per cent.

According to a preliminary report of the Bureau of Census, 11 firms reported sales of illuminating glass ware totalling $517,000,000 during August; this was 25 per cent under the August 1941 total and 3 per cent above July 1942.

Automatic tumbler production during August amounted to 4,497,767 dozens, or 9 per cent less than in last year's corresponding month. The January-August figures totalled slightly above those of the same period in 1941. Shipments in August were 4,531,993 dozens or 7 per cent below the total of a year ago, while the total of the eight months' period witnessed a slight increase over the previous year to 34,869,476. Stocks on hand amounted to 8,195,969 dozens, 4 per cent higher than in August 1941. The July figures for automatic tumblers necessarily omitted from last month's issue of THE GLASS INDUSTRY were: production—3,908,104 dozens; shipments—3,908,-104 dozens; stock on hand—8,2331,503 dozens.

Manufacturers' sales of machine-made table, kitchen and household glassware during August increased 27 per cent over August 1941 to a total of 3,047,938 dozens. For the 12-month period ending August 31 this trade amounted to 36,059,945 dozens as compared to a total of 37,617,162 dozens for the same period ending in 1941.

Employment and payrolls: Employment in the glass industry during August totalled 84,000 persons as compared to 81,000 in July and 88,000 in August 1941.

Payrolls in the glass industry during August amounted to $12,000,000 as compared to $11,500,000 in July and also of August a year ago. During the first eight months of 1942 glass manufacturers paid out about $96,500,000 in wages as compared to $84,000,000 last year.

REVISED WPB ORDER FURTHER STANDARDIZES CONTAINER WARE

The backbone of the wartime line of standard glass packages is catalogued in the amended and revised text of WPB Order L-103. Added to the original order, which took effect May 11, is a series of exhibits showing 28 standard glass container designs, principally for foods but available for other products as well. Other exhibits are attached to separate schedules under the order, showing the packages required to be used by four important glass using industries. In general, the glass container industry will be limited to the production of these containers for the products indicated and the packers will have to use them or go without glass. WPB has indicated in a press release that the issuance of the schedules in this way is for the purpose of suggesting that packers adopt the standardized containers wherever possible and as soon as possible. At present only the Liquor, Beer, Wine and Fruit Preserve industries have been given "mandatory orders" to use standardized containers. An important reason for hastening the use of such containers now is the saving in closure metal which they make possible.

The picture is still incomplete in many important respects, but the amended L-103, as issued Sept. 12, is a definite step towards its completion. Later there will be further additions to the lists of standardized containers to take care of various products whose packages are still unstandardized, or which are being converted to glass for metal conservation reasons. There are a number of such products. Drug and toilet articles containers also remain outside the standardized list, to mention two important classifications. How far it will be necessary to go towards 100 per cent standardization depends to a large extent on needs which may develop later. A very important step will be the issuance of a correlated "closure order" which should make it possible for suppliers and packers to plan with certainty regarding their future production. As it it today, a manufacturer may be able to assure himself of a glass supply but can get no assurance that he will be able to secure caps when it is time to pack the product. Every effort is being made to break this jam in the wartime packaging program.

The entire present container and closure set-up is in great need of a "simplification job." This may mean another revision of L-103, or a new order altogether, but it is quite certain that whatever revision is undertaken will be on the basis of the standardized containers which have been and are being developed. In other words, if there are further changes in the set-up, it will not change the packages. They are here to stay for the duration, if not longer. The economies in closure metal alone are of sufficient importance to assure the continued wartime use of these "WPB standard glass containers."

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THE GLASS INDUSTRY

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The Assessment of Performance of Tank Furnace for Melting Glass. *A Communication from the Furnace Committee of the Society of Glass Technology* (*Read by J. Greene*).

This communication dealt with a standard method of expressing the thermal performance of glass tank furnaces. In brief it was found that the influence of various factors such as size, temperature, rate of pull and fuel quality could be allowed for with reasonable accuracy and that a suitable formula which would express the efficiency of the furnace performance could be derived. This formula gives the performance of a furnace in terms of B.T.U.'s/sec. supplied to the furnace per sq. ft. of total area at no load and corrected to a standard area of 600 sq. ft. and a standard temperature of 1400° C. The method of derivation of the formula and the correction factors necessary for using the formula are given in detail.

The application of the formula to a wide variety of tanks was given and from this a classification of furnaces melting colorless glass was set up in terms of their performance. The classification used was as follows:

Performance Figure B.T.U.'s/sq. ft./sec.	Classification
Under 5	good
Between 5 and 6	fair
Between 6 and 7	poor
Over 7	bad

Factors such as diathermancy, age of furnace or glass quality are not taken into account in the formula. As far as diathermancy is concerned only a limited investigation of its effect has been possible but it was believed that, in general, the performance figures for furnaces melting colored glass would be in the order of 10 to 15 per cent lower (that is better) than for furnaces melting colorless glass. In the case of furnace age it is known that it has a considerable effect on fuel consumption and it is therefore necessary to state the furnace age at the time of the test. Of course if the performance figure is calculated at intervals the effect of tank age may be measured.

A list of some of the factors which contribute to poor performance was also given and included; inefficient gas producer, bad furnace operation, poor furnace design, poor construction, wrongly applied cooling and inadequate application of insulation.

Chemical Analysis of Cords and Stones in Glass. *By George Zarbo, H. S. Hunt, and D. C. Smith, Kimble Glass Co., Vineland, N. J.*

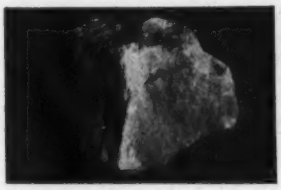
In determining the source and causes of stones or cords in glass the petrographic microscope is usually used. In many cases however the microscope technique does not give sufficient information and chemical analysis methods must also be used. When the stones or cords are large the ordinary macrochemical methods are satisfactory but when they are small a different technique must be used.

The technique used by the authors consists of, in the case of stones or cords that are more viscous than the glass, separating the area in question from the main body of glass by working over the blast lamp in such a manner that the area desired is clearly separated from the surrounding glass. When the stone or cord is less viscous than the glass a cutting and grinding technique is used. By use of very small grinding wheels (similar to those used in dentistry) the desired area may be separated from the main body of glass.

The cord or stone is then analyzed for either silica or alumina, or both, using semi-microchemical methods. In the case of silica a 50 mg. sample is used while in the case of alumina a 10 mg. sample is used. Microchemical equipment is used in all determinations. In general there is no transfer of precipitates as the procedure and apparatus is such that the contaminants are washed out and the weighings are made on the original micro filter beaker.

Determinations made on standard glass samples both by macro and micro methods showed good agreement. Results obtained on various stones, cords and glassy inclusions were also given and discussed.

THIS LITTLE PIECE
OF DOLOMITE LIMESTONE



HELPS GROW BIGGER AND
BETTER CROPS FOR UNCLE SAM

Lime (burned from limestone) is helping America's Food Production by correcting soil acidity and by being used as a spray for deterring pests and blights. It supplies the plant-foods calcium and magnesium. Together with fertilizer it is enabling farmers to raise crops that will help win the war.

Increased food crop yields come from the use of Dolomitic Lime. Virginia Truck Experiment Station Bulletin 91 shows the influence of Dolomite Lime upon the yield of Prime Potatoes. The yield per acre was increased 29% in 1935 over the average yield for the previous three years.

In four essential industries—agriculture, steel, glass, and building—lime and limestone are essential materials. The quarry output of Banner Lime and stone is being used by these essential industries for the all-out drive for victory.

THAT'S WHY *Banner-Lime* IS

Essentially yours

National Mortar & Supply Company
Pittsburgh, Pa.

Since 1907 . . . a good company to do business with

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	50.00	55.00
Precipitated material		55.00	60.00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00–16.00	18.00
Borax ($Na_2B_4O_7 10H_2O$)			
Granulated	In bulk, ton	42.50	....
Granulated	In bags, ton	46.00	56.00–61.00
Powdered	In bags, ton	51.00	61.00–66.00
Boric acid (H_3BO_3)			
Granulated	In bulk, ton	96.50	
Granulated	In bags, ton	100.00	111.00–116.00
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.09½–.09¾	.10
Synthetic (Artificial)	lb.	No supplies available.	
Feldspar—(published list prices)			
20 mesh	ton	11.00–13.25	
40 mesh	ton	11.50–13.75	
Granular	ton	11.75–14.00	
Semi-granular	ton	11.00–13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags.			
Fluorspar (CaF_2) domestic, ground, 96–98% (max. SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	34.00	....
In bags	ton	36.40	50.00
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0900	....
In 5 Ton lots	lb.	....	.0950
Less than 5 Tons	lb.	....	.10
Lime—			
Hydrated ($Ca(OH)_2$–MgO) (in paper sacks)	ton	8.50	9.50
Burnt (CaO–MgO) ground, in bulk	ton	7.50	....
Burnt, ground, in paper sacks	ton	9.50	9.50
Burnt, ground, in 191 lb. gross drums	Per drum	1.70	1.80
Kiln Dried ($CaCO_3$–$MgCO_3$) 10x30 mesh	ton	2.00	....
Kiln Dried ($CaCO_3$–$MgCO_3$) 16x20 mesh	ton	2.00	....
Nepheline Syenite, f. o. b. shipping point	In bulk, ton	12.00	15.00
Potassium carbonate—			
Calcined (K_2CO_3) 96–98%	lb.	.065	.0675
Hydrated 80–85%	lb.	.055	.0575
Salt cake, glassmakers (Na_2SO_4) in bags	ton	21.00–22.00	28.00–30.00
	in bulk	17.50	
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	.95	....
In barrels	Per 100 lb.	1.35	....
In Paper bags	Per 100 lb.	1.10	
In Burlap bags	Per 100 lb.	1.15	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls. 95% and 97%	Per 100 lb.	....	3.00–3.40
Bulk	Per 100 lb.	1.35	3.60–4.00
200 lb. bags		1.4675	....
100 lb. bags		1.5025	....

Special Materials

		Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)	lb.	.031–.034	.045
Aluminum oxide (Al_2O_3)		.07	.09
Antimony oxide (Sb_2O_3)	lb.	.15	.15½–.16½
Arsenic			
Glassmakers	lb.	.04¼	.04¾
Regular refined white	lb.	.04	.04½
Arsenic trioxide (As_2O_3) (dense white) 99% In barrels		.04–.04¼	.04½–.04¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	Open price.
Pyrophyllite (20% Al_2O_3)	ton	10.00	13.00
Sodium fluosilicate (Na_2SiF_6)	lb.	.07½	.09
Tin Oxide (SnO_2) in bbls.	lb.	....	Open price.
Titanium Oxide (ceramic grade)			
In bags	lb.	.14½	....
In barrels	lb.	.14¾	....
Zinc Oxide (ZnO)			
American process, bags	lb.	.07¼	.07½
White Seal, 150 lb. bbls.	lb.	.09¾	.10
Green Seal, bags	lb.	.09	.09¼
Domestic White Seal, bags	lb.	.09½	.09¾
Red Seal, bags	lb.	.08½	.08¾
Zircon			
Refined Granular (Milled .01–.02c higher)		.05¾	.06

Coloring Materials

		Carlots	Less Carlots
Barium selenite ($BaSeO_3$)	lb.	....	1.40–1.60
(Commercial, 25% Selenium)	lb.	....	.85
Cadmium sulphide (CdS)	lb.	....	1.10–1.15
Cerium hydrate—			
100 lb. drums and 600 lb. barrels	lb.	....	.60
Chrome Oxide Green, 400 lb. bbls.	lb.	....	.25–.28
Chromite (99% through 200 mesh)	ton	58.25	64.75
Chromite ore (air floated)	ton	58.25	64.75
Cobalt oxide (Co_3O_4)			
In bbls. 350 lbs. or more,	lb.	....	1.84
Less than 350 lbs.,	lb.	....	1.94
Copper oxide—			
Red (Cu_2O)	lb.	....	.20–.22
Black (CuO)	lb.	....	.19–.22½
Black prepared	lb.	....	Open price.
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.06½–.10
Black (Fe_3O_4)	lb.	....	....
Iron Chromate	lb.	....	.035–.05
Lead Chromate ($PbCrO_4$) in bbls.	lb.	....	.16
Lithium Carbonate	lb.	....	1.25
Manganese, Black Oxide African			
In Paper bags	ton	70.00	78.00
In Burlap bags	ton	71.75	79.75
In Casks	ton	74.00	82.00
Neodymium oxalate, 50 lb. drums	lb.	....	4.00
Nickel oxide (Ni_2O_3), black	lb.	....	.34–.40
Nickel monoxide (NiO), green	lb.	....	.35–.37
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals and Granular	lb.	.09½	.09¾–.10
Powdered	lb.	....	.10¼–.10½
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	....	.27
Powder blue	lb.	....	.21–.25
Rare earth hydrate—			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) in 100 lb. lots	lb.	....	1.75
In lesser quantities	lb.	....	1.85
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.07½	.07½–.07¾
Sodium chromate (Na_2CrO_7) Anhydrous	lb.	.08¾	.08¾–.09½
Sodium selenite (Na_2SeO_3)	lb.	....	1.50–1.65
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.65
Yellow	lb.	....	1.65
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.40	3.75–4.15
Flowers, in bags	Per 100 lb.	3.05	3.40–3.80
Flour, heavy, in 250 lb. bags	Per 100 lb.	2.95	3.30–3.70
Uranium oxide (UO_2) (black, 96% U_3O_8)			
100 lb. lots. Black	lb.	....	2.55
Yellow orange	lb.	....	1.65

Polishing Materials

		Carlots	Less Carlots
Emery, Turkish	lb.	.095	.09
Pumice Stone,			
American Ground FFF, FF, F	lb.	.06	.05
0, 0½, ½, 1	lb.	.06½	.06½
Putty Powder	lb.	Open price.	
Rotten Stone (Domestic)	lb.	.02¼	.03½
Rouge, Red	lb.	.18	.16
Black	lb.	.15	.18

HARRY V. WALLACE OF KIMBLE GLASS COMPANY DIES

Harry V. Wallace, Vice-President and Director of Sales of the Kimble Glass Company, died at his home in Vineland, N. J. on September 15th.

After experience in the sales field with the Socony-Vacuum Company and the Owens-Illinois Glass Company, Mr. Wallace joined the Kimble Glass Company in 1931 as Chicago Branch Manager. In 1939 he was transferred to the main office in Vineland and later in the year became Vice-President and Director of Sales.

Mr. Wallace was stricken with coronary thrombosis in January 1941 and though severely ill for more than a year had rallied remarkably and was anticipating resuming his duties when death intervened suddenly.

FERRO ENAMEL ACQUIRES W. B. LAWSON, INC.

Plans have been consummated by the Ferro Enamel Corporation to acquire all of the outstanding stock of W. B. Lawson, Inc., of Cleveland, Ohio. The Lawson corporation, organized by Mr. Lawson in 1940, are distributors for American Potash & Chemical Co., Duquesne Smelting Corp., Ferro Drier & Chemical Co., Michigan Alkali Co., and others. The corporation will continue under the direction of Mr. Lawson, a former vice-president and director of the Harshaw Chemical Company and for many years a director of the International Nickel Company.

DUPONT'S CEL-O-SEAL FINDS WAR JOB

The tight fitting cellulose bottle hoods made by DuPont, known as Cel-O-Seal, are now being used by airplane manufacturers to protect ope ends of fuel and hydraulic lines, pipes, and tubes, during assembling and shipping. Cel-O-Seal effectively closes the tubes against dirt, protects them from rust, and discourages plugging of lines by saboteurs since a broken seal is evidence of tampering. It also releases critical materials formerly used such as cork, metal and rubber.

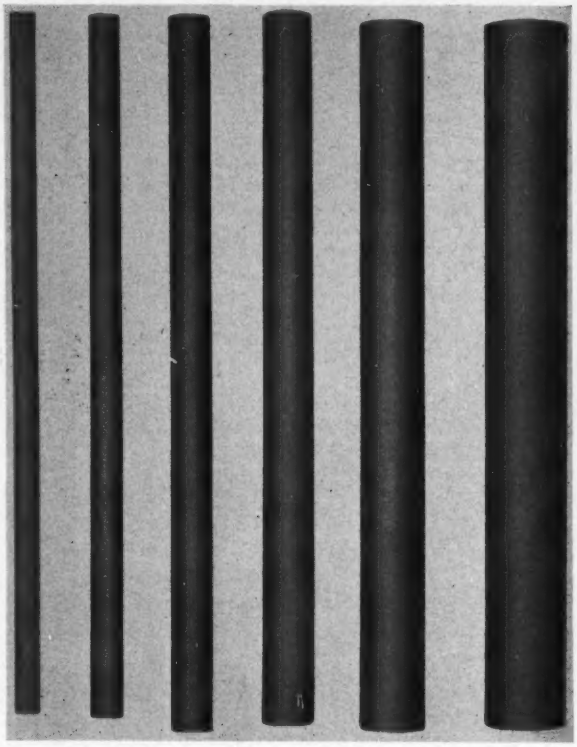
The seals, made from wood pulp in a variety of sizes, are bright red in color and delivered in a container of non-corrosive and non-toxic liquid. Application to the tube is made while the cap is wet and during the few minutes which it takes to dry the cap shrinks to a tight fit around the tube opening. Thus it is adaptable as a seal for varying sizes and irregular shapes.

MISS MINITA WESTCOTT WITH MIRROR MANUFACTURERS ASSOCIATION

Miss Minita Westcott has been appointed Acting Secretary of the Mirror Manufacturers Association, succeeding Lambert H. Miller. Closely associated with the glass business for 21 years, Miss Westcott was assistant to Mr. North Storms when he served as Secretary to the Association from 1928-1936. It was at this time the booklet "Mirrors in the New American Home" was produced, its preparation and publishing being handled in large part by Miss Westcott.

WANTED: Man with thorough and long experience in the manufacture of thermos bottles. Plant located in Mexico. Reply giving full information, experience, age and training to Box 53, The Glass Industry, 55 West 42nd Street, New York, N. Y.

Malleable Iron Rods for plugging Moulds



1/8" 3/16" 1/4" 5/16" 3/8" 1/2" 5/8" x 6"

IN the manufacture of Malleable Rods a "white iron" is produced Fe3C. The carbon is present in the combined form. The "white iron" castings are annealed or graphitized so that the final structure consists of ferrite (Fe) and free carbon (C) which is in the form of "temper" carbon.

This material is very soft and will pein readily.

Machinability

It is generally known, in commercial operations, Malleable iron machines more readily than other ferrous materials of equal tensile properties.

May we send you a descriptive booklet or answer questions on your specific problems?

Price of 15c per lb. F.O.B. Rockford effective Feb. 1st.

GUNITE FOUNDRIES CORPORATION

ROCKFORD ILLINOIS

Established 1854

NEW EQUIPMENT AND SUPPLIES

T. L. SMITH GLASS BATCH MIXER

A newly designed glass batch mixer of the tilting drum type has been announced by the T. L. Smith Company of Milwaukee. The drum support tilting frame and its supporting pedestals are of the electric-welded, box girder type. The drum is dust sealed during the entire mixing cycle.

Mixing is accomplished by a series of V-shaped blades mounted clear of the drum shell. It is claimed that the mixed batch will not segregate during discharge since the mixing process continues during the discharge operation. A new type of pneumatic or hydraulic cylinder tilts the drum to an angle of 60 degrees, discharging the entire batch with no ingredients remaining in the drum.

Other features include enclosed unit transmission case with heat treated, alloy steel, machine cut gears mounted on plined alloy steel shafts. The electric motor is direct-connected to the unit transmission case.

DIRECT READING CALIPER

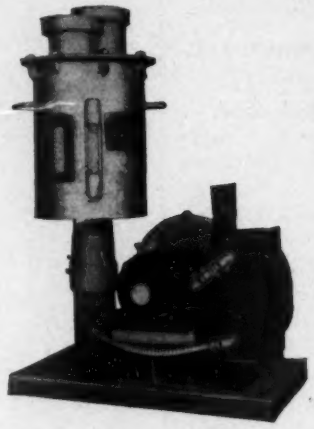
Designed for measurement over beads, rims, depressions and lathe work, the Corlin Manufacturing Company of Minneapolis has developed a caliper which is simple to use, accurate and speedy. The measurement scale is marked for easy reading. Case hardened with ebonite finish.

GLASS SHATTERING PROTECTION

To prevent flying glass in the event of of explosions Glass Protector Products, Inc., have produced Cotopane Glass Protector. It is easily applied by simply brushing on the adhesive and applying Cotopane, a mesh-like plastic, to the glass. It is claimed to adhere permanently, permits 90 percent light penetration, is water resistant and flexible.

MOISTURE PREVENTION FOR OIL AND CHEMICAL TANKS

A new device for preventing the entrance of atmospheric moisture into oil and chemical tanks has been developed by Pittsburgh Lectrodryer Corporation and is known as a Lectrobreather. Only dry air is permitted to enter the tank when empty or when air enters due to temperature drops. Air leaving the tank, being thoroughly dry, has a partial reactivating effect making possible long periods between reactivations.



Lectrobreathers are mounted directly on the tank or piped to it and are equipped with color indicators for determining when reactivation is needed. The reactivators are built for electric operation as standard for all units or for steam operation on the two larger units. Special Lectrobreathers are available for use on transformers or other equipment where atmospheric moisture is harmful.

TEMPERATURE CONTROL FOR MULTIPLE BURNER OVEN

To maintain even heat throughout a multiple burner oven or kiln regardless of heat loss at the door, the Wheelco Instruments Company has designed an application which controls the burners so that those at the extreme ends burn while those toward the center are out.

When operating the equipment on a continuous car-type principle with a temperature at the start differing from the temperature at the end of the process, control instruments at the ends of the oven are set accordingly and the instrument controlling center burners is set at an in-between point. The control provides the exact temperature desired at all points within the oven for both continuous car or batch-type operation. Protection against instrument thermocouple failure is provided by a Limitrol which shuts off fuel by names of a solenoid valve.

L.O.F. DONATES ALUMINUM

The Libbey-Owens-Ford Glass Company has turned over to the government for use in building bombers its stock of 82,233 pounds of aluminum which originally was fabricated for decorative store fronts. The donors said they preferred that the stock be used in bombers to "decorate" Axis war fronts. In its present fabricated form the aluminum is valued at $52,450.98. Under the government basis of valuation L.O.F. will receive $19,922.58 for the stock.

ARMY-NAVY PRODUCTION AWARD TO BAUSCH & LOMB

For the third time in little over a year the Bausch & Lomb Optical Company have been honored for exceptional achievement in the production of war equipment. The first Navy E was awarded to this company, and later the first Navy burgee with service star. Their most recent award is the Army-Navy E.

CATALOGS RECEIVED

General Electric-Radio, Television and Electronics Dept., Schenectady, N. Y. A quick-selection and comprehensive chart of electronic tubes for industry, with technical data on applications and tubes.

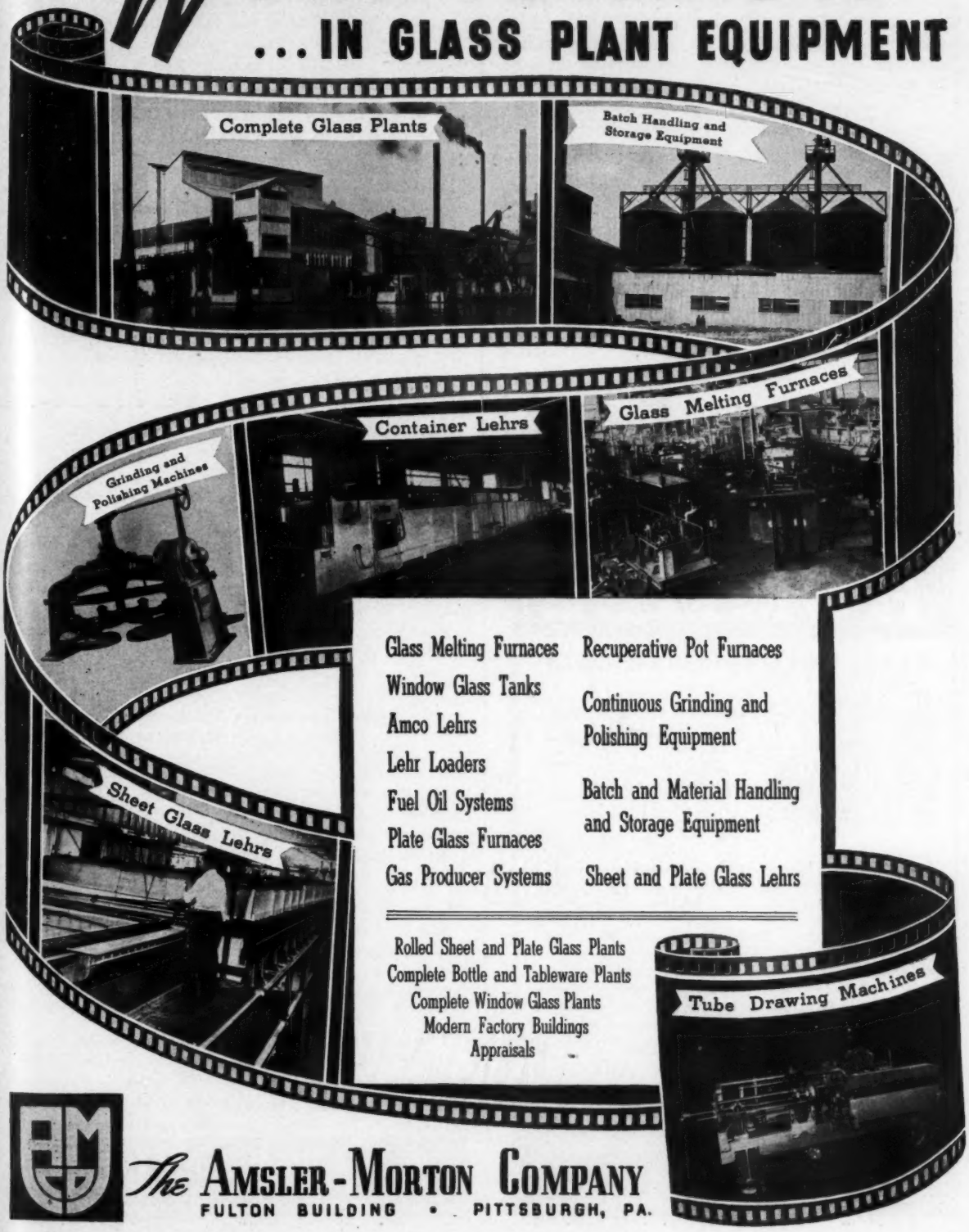
Foxboro Company, Foxboro, Mass. Catalogue 95A is a convenient reference handbook describing the full line of instruments handled by this company for the measurement and control of industrial process conditions. It is divided into ten sections; six covering instruments and accessories appropriate to a particular field of application, the remainder covering combination instruments, valves, etc. Contents are cross-indexed.

Stearns Magnetic Mfg. Co., Milwaukee, Wis. An 8-page brochure, "The House of Stearns Magnetic Magic" explains the subject of separation, concentration, reclamation and purification of materials by magnetic separation methods and outlines advantages of various types of magnetic separators. Written for the factory official, metallurgist and engineer to provide information not generally included on reference shelves.

Bulletin 25-C describes design and construction of Stearns suspended magnets with illustrations of applications.

American Brake Shoe & Foundry Company, American Manganese Steel Div., Chicago, Ill. Bulletin 642-C shows in clear illustrations with descriptions crusher, grinding mill and pulverizer parts made from Amsco Manganese Steel. Included is a page of questions and answers on "What is manganese steel?"

World-foremost
...IN GLASS PLANT EQUIPMENT



Glass Melting Furnaces
Window Glass Tanks
Amco Lehrs
Lehr Loaders
Fuel Oil Systems
Plate Glass Furnaces
Gas Producer Systems
Recuperative Pot Furnaces
Continuous Grinding and Polishing Equipment
Batch and Material Handling and Storage Equipment
Sheet and Plate Glass Lehrs

Rolled Sheet and Plate Glass Plants
Complete Bottle and Tableware Plants
Complete Window Glass Plants
Modern Factory Buildings
Appraisals

The AMSLER-MORTON COMPANY
FULTON BUILDING • PITTSBURGH, PA.

RESEARCH DIGEST

(*Continued from page* 387)

content by removing the iron stain from the sand grains, much of the paper discusses the various impurities that may be found in sands and the methods that can be used for the removal of such impurities. A table of examples of treatment and results obtained is given which lists nearly twenty sands, the source of which ranges from Maine to California. The iron content, principal impurities, suggested treatments for purifying the sand and the results obtained are also given.

For those who are investigating such sands a test procedure is outlined which if followed will allow the acceptability of the sand to be readily determined.

THE SHARP-SCHURTZ COMPANY

CHEMISTS AND CONSULTING ENGINEERS

FOR THE GLASS INDUSTRY

LANCASTER, OHIO U. S. A.

HOMMEL

GLASS COLORS • CHEMICALS

COLORS—Acid and Alkali Resistant • Transparent and Opaque • White and Colored Enamels • Weatherproof Colors • Fluxes . . . . Ices • Liquid Lustre Colors • Burnish Gold.

CHEMICALS—Acids • Ammonium Bifluoride • Antimony Oxide • Arsenic • Barium Carbonate • Bone Ash • Borax • Cadmium Sulphide • Chrome Green Oxide • Cobalt Oxide • Copper Oxide • Cryolite • Feldspar • Fluorspar • Iron Chromate • Iron Oxides • Manganese Dioxide • Potassium Carbonate • Potassium Bichromate • Salt Cake • Selenium • Soda Ash • Sodium Antimonate • Sodium Bichromate • Sodium Nitrate • Sodium Silico Fluoride • Sodium Uranates • Sulphur • Titanium Dioxide • Uranium Oxide • Zirconium Oxide • Zirconium Silicate.

THE O. HOMMEL COMPANY

209 FOURTH AVE. PITTSBURGH, PENNA.

Phone ATlantic 1195

OPTICAL GLASS FOR WAR PRODUCTION STARTED BY L.O.F.

Production of optical glass as part of its war program has been begun by Libbey-Owens-Ford Glass Company, one of the nations' largest manufacturers of window and flat glass. Precision glass for anti-aircraft and machine gun sights is being cut to shape from sections of large sheets of highly ground and polished plate glass. Light filters or colored precision glass also are being manufactured in quantity for military use.

CHANGES IN STAFF OF CERAMIC DEPARTMENT AT UNIVERSITY OF ILLINOIS

The Department of Ceramic Engineering at the University of Illinois has opened its fall session with several changes on its staff. Dr. A. I. Andrews has assumed the duties as Head of the Department upon the retirement of Professor C. W. Parmelee. Dr. A. E. Badger was promoted from Research Assistant Professor to Research Associate Professor of Ceramic Engineering, and Dr. C. G. Harmon was promoted from Instructor to Assistant Professor of Ceramic Engineering. C. R. Filippi, B. S. '37 in Ceramic Engineering, was appointed an assistant in the department. He was formerly associated with the Illinois Brick Company as development engineer. A. C. Ottoson is leaving the University to take a position with the Imperial Glass Corporation.

JOSEPH K. CLOSE BECOMES O-I MARKET RESEARCH HEAD

Joseph K. Close, advertising and publicity man for the Owens-Illinois Glass Company for the past several years, has been appointed manager of its newly created Division of Market Research. Mr. Close was formerly associated with the United States Advertising Corporation as account executive on the Owens-Illinois advertising program.

NEW SECOND VICE-CHAIRMAN FOR GLASS DIVISION

Mr. C. K. Lyon of Armstrong Cork Company has been appointed temporary second vice-chairman of the Glass Division of the American Ceramic Society. The appointment was made necessary through the resignation of this post by Professor C. W. Parmelee.

• Roy W. Olsen, treasurer-controller of the Liberty Glass Company, Sapulpa, Okla., has been elected to active membership in the Controllers Institute of America, an organization devoted to improvement of controllership techniques.

• Mr. E. W. Ritter, recently appointed as Assistant to Mr. G. W. Cole, President of the Corning Glass Works, has been called to Washington for work in connection with the U. S. Signal Corps. Formerly vice president of R. C. A., Mr. Ritter expects his special assignment at Washington will require about three months of his time, after which he will return to his duties at Corning. All divisions of the Corning Glass Works are heavily engaged in war production.

FLUXTITE by LACLEDE-CHRISTY

. . . the tank block of accurate structure balance made by ceramic experts from a precision blend of fire clays, including the famous Missouri Washed Pot Clays.

Fluxtite and its companion products, Laclede's Super Refractory Mix 89 and Laclede's Refractory Upperstructure, have been and are now meeting the strict requirements of the producers of soda-lime, boro-silicate and all other glasses.

Laclede-Christy, "The Glass Industry Specialists," have everything in refractories for the glasshouse. Consult with . . .

LACLEDE-CHRISTY

The World's Largest Producers of Glass House Refractories

ST. LOUIS . . TOLEDO

GLASS SLICING MACHINES

• We manufacture a variety of wet glass slicing machines for solid glass bars, glass tubing, etc. We can also supply a full line of special glass working machinery for the production of television tubes, fluorescent tubes, incandescent lamps, glass ampules and vials. Glass working lathes and laboratory equipment of all kinds. Cross Fires and Torches. Ask for our catalogue.

•

EISLER ENGINEERING CO.
CHAS. EISLER, Pres.
742 SOUTH 13TH STREET
(Near Avon Avenue)
NEWARK, N. J.

GLASS SPECIALTIES

Transparent Colored Blown Sheet Glass
Solid Pot Opal Blown Sheet Glass
Flashed Opal Blown Sheet Glass
Colonial Antique Colored Glass
Heat-Ray Resisting (Cool Glass)
"TWIN-RAY"—the scientific illuminating glass.

HOUZEX

L. J. HOUZE
CONVEX GLASS CO.
Point Marion, Pennsylvania
New York Office: 110 West 40th St.
Chicago Office: 1597 Merchandise Mart
"IF IT'S MADE OF GLASS, ASK US FIRST"

BORAX & BORIC ACID

99½—100% PURE

Stauffer

NITRATE OF POTASH
CAUSTIC SODA
SULPHUR

STAUFFER CHEMICAL CO.
420 Lexington Ave., New York, N.Y. 624 California St., San Francisco, Cal.
230 N. Michigan Ave., Chicago, Ill. 5555 Flower Street, Los Angeles, Cal.

GLASS INSPECTION with the *Polaroid*

Spectacle type polariscope

THE polarizing spectacle, mounted in unit with sensitive tint plate of 565 millimicrons, presents an absolutely uniform field of large aperture, strains showing up in sharply defined and correct colors.

Standard size apertures are 6" diameter and 12" diameter; but any special size to meet your requirement can be made. They are all light in weight and a leather case can be furnished where required. The 6" unit is suggested for either plant inspection uses or—as a portable unit for the trouble shooter or the salesman where a large aperture, compact unit of light weight is desirable.

THE POLARIZING INSTRUMENT CO.
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SOLVAY

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LOW MELTING GLASSES . . .

(*Continued from page* 386)

only strong bonds, are short. On the other hand, complex glasses containing a variety of bonds ranging from the strong Si-O bond to the weak K-O bond, have a long working range.

(d) Divalent Network Modifiers, Alkaline Earths—The effect of the replacement of monovalent (alkali) ions by divalent (alkaline earth) ions cannot be quantitatively predicted on the basis of structural changes. If we substitute CaO for Na_2O, we do not change the oxygen ratio, but we substitute one $Ca^{2}+$ for two $Na+$; the resulting effect on meltability is complicated and can hardly be interpreted by the ionic potential of the respective ions. If we substitute 2CaO for one Na_2O, we have indeed accomplished the exact exchange of one Na^+ ion by one Ca^{++} ion. In this case the meltability is increased for two reasons: (aa) The sodium ion is replaced by the calcium ion of higher valency. (bb) Two CaO introduce twice as much oxygen as one Na_2O and consequently

The main reason of the introduction of calcium oxide increase the oxygen ratio of the glass.
is not related to meltability, but to increased chemical resistivity caused by the chemistry of calcium ions in the process of attack.

The effect of an exchange of various divalent ions such as Ca, Sr, Ba, Zn, Mg, is not as simple as in the case of the alkalis and cannot be completely represented as a function of ionic size. Their own bond to oxygen is more prevalent even at lower concentrations and frequently their position in the structure becomes comparable to that of silicon. This is the case with Zn, which may act as a flux or increase melting temperatures, depending on the overall composition. In other words, Zinc may assume network former functions.

The complexity effect is as pronounced as in the case of monovalent ions. Barium glazes may have to be fired at a higher temperature than the corresponding Ca glazes. Still the addition of Ba in certain concentrations is the basis of many relatively low maturing glazes. The increasing availability of Strontium will add to the possibilities ot complex alkaline additions wherever low firing ranges in the absence of lead are desirable.

5. Fifth Structural Change: Monovalent Anions

The last principle of lowering the melting range of a vitreous ceramic material is the replacement of the oxygen network, which forms the backbone of the ordinary glass, by a network of anions of comparable size and character but lower valency. Theoretically this can be accomplished by substituting the halogen ions F^-, Cl^-, Br^-, I, for O^2.

(a) The Weakened Model Glasses—The halogen ions being monovalent have just half the valency of oxygen. If this replacement shall be complete and a continuous network still be maintained, the valency of the network former has to be two instead of four. The ideal network former in the fluorine glass will be represented by an ion which has the same size as silicon and a valency of two instead of four. This reasoning was introduced by Goldschmidt and applied to the development of weakened glass structures which are low melting models for the study of the higher melting vitreous and crystalline silicates. The basis of this glass was beryllium

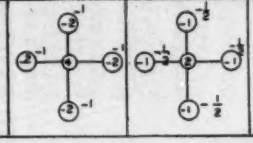
	SiO_2	BeF_2	
Radius Si	0.41	0.31	Radius Be
Radius O	1.32	1.33	Radius F
Ratio of Radii $\frac{Si}{O}$	0.32	0.23	Ratio of Radii $\frac{Be}{F}$
Limits of this Ratio for Tetrahedral Arrangement	0.225 – 0.414	0.225 – 0.414	Limits of this Ratio for Tetrahedral Arrangement
Valency Si	4	2	Valency Be
Valency O	2	1	Valency F
Ratio of Valencies	2	2	Ratio of Valencies
Oxygen Ratio $\frac{O}{Si}$	2	2	Fluorine Ratio $\frac{F}{Be}$
Structure			Structure

Table XI. Comparison of SiO_2 and BeF_2 Glass.

fluoride and Table XI illustrates its relationship to SiO_2.

The conditions for tetrahedral arrangement are fulfilled, because this ratio lies between .225 and .414. The identical tetrahedral arrangement is, therefore, possible in SiO_2 and BeF_2, but the valencies of BeF_2 are only half of the values in SiO_2. A lower sum of valencies is known to cause weak structures and low melting temperatures. BeF_2 forms glasses with various fluorides just as SiO_2 with other oxides. In this empire of fluorine glasses the "fluorine ratio" plays the role of the oxygen ratio. Their thrillingly low melting ranges and their other outstanding properties cannot be used because of their inferior chemical stability.

(b) Fluorine-Oxygen Glasses—To a certain extent fluorine can partly substitute for oxygen in oxygen glasses, that is in regular silicate, phosphate or borate glasses. The introduction of fluorine is limited by the fomation of volatile compounds. Larger amounts may also form crystalline fluorides, or devitrification, or opal glasses. In wide areas, especially of alumosilicate and phosphate glasses, however, clear glasses do exist which contain an appreciable percentage of fluorine. The softening effect of alkali and alkaline earth fluorides replacing the oxides is considerable, because in addition to the weakness of the fluorine bonds the oxygen + fluorine ratio is also increased. (Table XII.)

Composition	$4Na_2O + 12SiO_2$			$3Na_2O + 2NaF + 12SiO_2$		
	NWM	NWF	O	NWM	NWF	O + F
Oxygen Ratio	$\frac{Na}{8}$	$\frac{Si}{12}$	28	$\frac{Na}{8}$	$\frac{Si}{12}$	29
	$\frac{28}{12} = 2\frac{4}{12}$			$\frac{29}{12} = 2\frac{5}{12}$		

Table XII. Increase of $\frac{O+F}{Si}$ Ratio with substitution of F for O.

If less than the equivalent amount of NaF is introduced in the place of Na_2O the softening effect may be less considerable, but the Na concentration has been decreased. This reminds us of the beneficial effect of phosphates. In both cases, lack of alkali warrants higher resistivity.

From the oldest days to our time, fluorides specifically fluorspar, have been used in various ceramic ware in order to provide an additional flux. Chlorine has been used for this purpose occasionally. In the series I-Br-Cl-F the ionic size decreases towards F. No systematical determinations of the melting behavior are available, since the study of I, Br. and Cl-glases is made difficult by the volatility of halides. In the next instalment the limitations are discussed which prevent the unrestricted application of the principles leading to softer glasses.

†See Part I. September issue, page 338.

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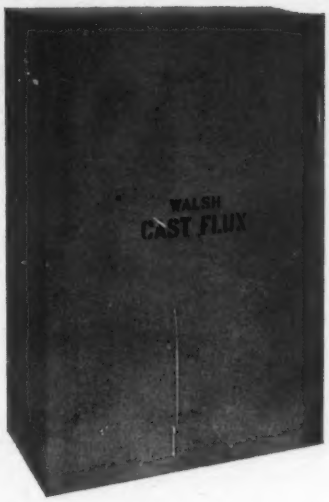

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